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An Investigation of the Criterion Measures of Rate and Duration During Performance of Selected Articulatory Motor Tasks by Normal Speakers.

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An Investigation of the Criterion Measures of Rate and Duration During Performance of Selected Articulatory Motor Tasks by Normal Speakers

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ABSTRACT

The purpose of this investigation was to investigate factors which may be significant in the employment of consonant-vowel (CV) utterances for the measurement of speech motor proficiency. Subjects were 15 male and 15 female speakers 17 years of age with no known speech or hearing disorders. The test items consisted of 15 single, 15 two syllable and 15 three syllable CV utterances composed of the consonants /p, b, t, d, k, g, f, v, θ, ð, s, z, ʃ, m, n / combined with the vowel /ʌ/. Subjects repeated each of the 45 test items as rapidly as possible for as long as possible during one maximum exhalation. Each subject performed the test items during two different test periods with two performances within each test period. Criterion measures were rate, the number of syllables per second and duration, the length in time in seconds from the onset of the first syllable to the termination of the last correctly produced syllable of a repetitive series during a single exhalation. Factors which were studied included: sex, short-term and long-term reliability, place of articulation, manner of formation, voicing, and number of syllables in the test item.

Results of this study indicated:

1. There are no significant differences between overall test results of males and females for either rate or duration measures. However, males and females perform differently at different test times and with various test items. These differences are obscured in comparisons of total results of one sex with total results of the other sex.

2. No significant differences were found for measures obtained within test periods (short-term reliability) for either rate or duration.

3. Measures obtained during two different test periods were significantly different. Means for all subjects combined were higher for rate and for duration in the second testing period. Means for each testing period were highly correlated with one another (rate, $r = .94$; duration, $r = .90$).

4. Test items were significantly different. These differences were related to place of articulation, manner of formation, voicing and number of syllables in the test items.

5. Rate increased linearly and quadratically when the number of syllables in the test item was increased. Duration decreased linearly and quadratically when the number of syllables in the item increased.

CHAPTER I

INTRODUCTION

Speech pathologists have long recognized that poor motor ability is one of several possible etiological factors in the production of articulatory deviations. Motor function has been explored through employment of a variety of tasks. Some of these tasks emphasize gross motor activities, i.e., running, jumping and walking a balance beam. Other tasks involve only the speech structures. One of the commonly used procedures to evaluate articulatory behavior employs diadochokinesis.

Diadochokinesis has been defined as the ". . . act or process of repeating at maximum speed some simple, cyclical, reciprocating movement. . . ." (West, Ansberry, and Carr, 1957, p. 595). Examples include repeating the movement of lowering and raising the mandible, occluding and opening the lips, and tapping with the finger (Wood, 1957, p. 54). The elements of maximum speed, rhythm, repetition and reciprocal directionality of movement appear to be implicit aspects of diadochokinesis.

One of the ways to explore the elements of speed, repetition and reciprocity of speech movements is to have a subject repeat consonant-vowel (CV) syllables over a period of time. A review of the literature indicates that the syllables of /pʌ/, /tʌ/ and /kʌ/ are used often, both as single tasks and as a combined series, /pʌtʌkʌ/ .

Most investigations of speakers with normal speech have used only the CV syllables given above, with the exception of Lundeen's study (1950). However, several comparative studies (Matthews and Byrne, 1953; Albright, 1948; Maxwell, 1953; Canter, 1965) of normal and defective speakers suggest that other syllables may differentiate speakers with or without speech disorders. Furthermore, other researchers (Prins, 1962; Ptacek, 1966) indicate that polysyllabic sequences nearly always differentiate between adequate and inadequate performance.

Although most studies have reported only rate measures for normal and defective speakers, Ewanowski (1964) studied the factor of duration as well as rate in an investigation of the articulatory skills of normal speakers and speakers with Parkinson's Disease. He reported that duration measures denoted significant differences between the two groups of speakers, although rate measures were not significantly different. With the exception of Ewanowski's study, little consideration has been given to duration measures.

PURPOSES

The employment of rapid, repetitive productions of CV syllables and polysyllabic utterances as a means for testing speech motor proficiency is based on incomplete knowledge at the present time. Little is known, for example, about the effect of consonants other than /p/ ,/t/ or /k/ in tests involving repeated utterances of single syllables. The review of the literature suggests that CV polysyllabic utterances merit more attention than they have received thus far. The assumption also appears warranted that duration of utterances should be investigated as carefully as rate.

If extension of the length of utterances is conjoined with the set of possible substitutions for the voiceless consonants /p/, /t/, and /k/, and with the possibility of employing either rate or duration as a criterion measure, a large number of potential combinations and permutations result. A thorough investigation of the factors listed above required that both their short term and long term reliability be determined.

The purpose of this present study is to delimit a set of factors which may be significant in the employment of CV utterances for the measurement of speech motor proficiency. The set of factors examined include: place of articulation, manner of formation, voicing, number of different syllables in the utterances and the interaction of place of articulation with the manner of formation.

DEFINITIONS OF TERMS

For purposes of the present study, the terms rate, duration, short term reliability and long term reliability are defined as follows:

Rate: Rate is defined as the number of syllables repeated per second.

Duration: Duration of performance is defined as the length of time in seconds from the onset of the first syllable to the termination of the last correctly produced syllable of a repetitive series during a single exhalation.

Short term reliability: Short term reliability is test-retest reliability of measures obtained within the same test period.

Long term reliability: Long term reliability is test-retest reliability of measures obtained in two comparable test periods.

HYPOTHESES

The relatively large number of null hypotheses tested in the study are listed as major and (where appropriate) minor hypotheses.

Major Hypothesis 1: The rate of performance in the repetition of syllabic utterances does not differ significantly by sex.

Major Hypothesis 2: The duration of performance in the repetition of syllabic utterances does not differ significantly by sex.

Major Hypothesis 3: Rate measures obtained for repetitions of syllabic utterances within test periods do not differ significantly.

Major Hypothesis 4: Duration measures obtained for repetitions of syllabic utterances within test periods do not differ significantly.

Major Hypothesis 5: Rate measures obtained for repetitions of syllabic utterances between test periods do not differ significantly.

Major Hypothesis 6: Duration measures obtained for repetitions of syllabic utterances between test periods do not differ significantly.

Major Hypothesis 7: Rate of repetitions of syllabic utterances is not related to place of articulation when manner of formation is held constant.

Hypothesis 7a: Rate of repetitions of syllabic utterances does not differ significantly between labial and lingua-alveolar CV syllables.

Hypothesis 7b: Rate of repetitions of syllabic utterances does not differ significantly between labial and lingua-velar CV syllables.

Hypothesis 7c: Rate of repetitions of syllabic utterances does not differ significantly between labio-dental and lingua-dental CV syllables.

Hypothesis 7d: Rate of repetitions of syllabic utterances does not differ significantly between CV syllables with labio-dental and lingua-dental consonants and CV syllables with lingua-alveolar consonants.

Hypothesis 7e: Rate of repetitions of syllabic utterances does not differ significantly between CV syllables with labio-dental and lingua-dental consonants and CV syllables with lingua-palatal consonants.

Hypothesis 7f: Rate of repetitions of syllabic utterances does not differ significantly between lingua-alveolar and lingua-palatal CV syllables.

Hypothesis 7g: Rate of repetitions of syllabic utterances does not differ significantly between lingua-alveolar and lingua-velar CV syllables.

Major Hypothesis 8: Rate of repetitions of syllabic utterances is not related to manner of formation.

Hypothesis 8a: Rate of repetitions of syllabic utterances does not differ significantly between plosive and fricative CV syllables.

Hypothesis 8b: Rate of repetitions of syllabic utterances does not differ significantly between plosive and nasal CV syllables.

Hypothesis 8c: Rate of repetitions of syllabic utterances does not differ significantly between nasal and fricative CV syllables.

Major Hypothesis 9: Rate of repetitions of syllabic utterances does not differ significantly for voiced and unvoiced consonants in CV syllables.

Major Hypothesis 10: Rate is not related linearly to the number of syllabic utterances in the set of tasks.

Major Hypothesis 11: The duration of repetitions of syllabic utterances is not related to place of articulation when manner of formation is held constant.

Hypothesis 11a: Duration of repetitions of syllabic utterances does not differ significantly between labial and lingua-alveolar CV syllables.

Hypothesis 11b: Duration of repetitions of syllabic utterances does not differ significantly between labial and lingua-velar CV syllables.

Hypothesis 11c: Duration of repetitions of syllabic utterances does not differ significantly between labio-dental and lingua-dental CV syllables.

Hypothesis 11d: Duration of repetitions of syllabic utterances does not differ significantly between CV syllables with labio-dental and lingua-dental consonants and CV syllables with lingua-alveolar consonants.

Hypothesis 11e: Duration of repetitions of syllabic utterances does not differ significantly between CV syllables with labio-dental and lingua-dental consonants and CV syllables with lingua-palatal consonants.

Hypothesis 11f: Duration of repetitions of syllabic utterances does not differ significantly between lingua-alveolar and lingua-palatal CV syllables.

Hypothesis 11g: Duration of repetitions of syllabic utterances does not differ significantly between lingua-alveolar and lingua-velar CV syllables.

Major Hypothesis 12: Duration of repetitions of syllabic utterances is not related to manner of formation.

Hypothesis 12a: Duration of repetitions of syllabic utterances does not differ significantly between plosive and fricative CV syllables.

Hypothesis 12b: Duration of repetitions of syllabic utterances does not differ significantly between plosive and nasal CV syllables.

Hypothesis 12c: Duration of repetitions of syllabic utterances does not differ significantly between nasal and fricative CV syllables.

Major Hypothesis 13: Duration of repetitions of syllabic utterances does not differ significantly for voiced and unvoiced consonants in CV syllables.

Major Hypothesis 14: Duration is not related linearly to the number of syllabic utterances in a set of tasks.

CHAPTER II

REVIEW OF THE LITERATURE

Review of the literature indicates that researchers have employed many approaches to the investigation of motor ability. To facilitate interpretation of the reported findings, the approaches employed are discussed according to tasks, subjects and methodology.

TASKS

Non-Oral, Non-Speech Tasks

Non-oral, non-speech tasks included in the research literature measure general body motor coordination (e.g., balance, hopping, running, rail walking); motor strength (e.g., grip, relative reach during standing and jumping); motor kinesthesia (e.g., ability to duplicate a specific pull against a spring operated plunger); laterality (e.g., hand and eye dominance); and eye-hand coordination (e.g., putting pellets in a bottle, tracing patterns). The criterion measures usually employed include accuracy of performance; speed of performance; and rate of task completion within a specified time period. Not all studies have used all three measures.

General motor coordination. To explore the hypothesis that normal and defective speakers differ in their gross motor coordination, researchers have tested performance on tasks requiring agility and balance. Dickson (1962), Jenkins and Lohr (1964), and Bilto (1941) used a battery of tests to explore the variable of general motor ability while Albright (1948), Mase (1946), and Prins (1962) used only a single measure.

Dickson (1962) used the Oseretsky Tests of Motor Proficiency in his investigation. The Oseretsky Tests include six subtests measuring General Static Coordination, e.g., maintaining balance while standing on one leg; Dynamic Manual Coordination, e.g., cutting paper with accuracy within a given time period; General Dynamic Coordination, e.g., maintaining balance while hopping; Motor Speed, e.g., placing coins in a box with accuracy and speed; Simultaneous Voluntary Movements, e.g., tapping alternately with feet; and Synkinesia, e.g., clenching teeth without overflow of forehead wrinkling.

Dickson reported that the Oseretsky Tests showed a significant difference (0.01 level) between a group of first, second, and third grade children who had spontaneously outgrown functional articulation errors and a similar group of children who had retained articulation errors. The author did not indicate relationships between particular subtests and speech skills.

Jenkins and Lohr (1964) also reported that the Oseretsky Tests showed a significant difference in favor of the normal speakers (0.01 level) in their investigation of first grade children with severe articulation problems (three or more sound errors) and those without speech defects. The authors indicated that the speed tests were not sensitive measures in their study. Analysis of the remaining five subtests indicated that the control group was consistently superior to the experimental group of articulatory defective speakers, although the amount of difference varied from subtest to subtest. The categories of Dynamic Manual Coordination and Simultaneous Movement Coordination showed the greatest differences. There was a wide distribution of motor quotients in both groups and no direct cause and effect relationship between specific motor tasks and articulatory disorders was established.

Bilto (1941) tested 180 children between the ages of 9 and 18 years with the Brace Motor Ability Test Battery, the Nielsen-Cozens Jump and Reach Test and an eye-hand coordination task of ball bouncing. The Brace Motor Ability Test Battery consists of seven subtests which measure agility and balance and three subtests which measure strength and control. The Nielsen-Cozens Jump and Reach Test measured the difference between a mark of maximal reach when standing still and when jumping.

The 180 children included 34 stutterers, 56 articulation cases and 90 children without speech disorders. The author found that two-thirds of the stutterers and articulation cases were inferior to the control group on all three tests, but inferiority was not characterized by failure in any specific ability. Performances of the stutterers and articulatory cases were not distinguished by any specific ability. The significance of differences was not reported.

In contrast to the findings of the investigators above, Maxwell (1953), Albright (1948), Mase (1946), and Prins (1962) reported that their particular measures of motor coordination did not differentiate between defective and normal speakers. Maxwell (1953), in his exploration of motor coordination, used portions of the Oseretsky Tests to evaluate "station" and four walking tests to evaluate gait. He found no statistically significant differences between the performances of boys aged seven, eight, and nine years with good articulation matched with boys with defective articulation. Albright (1948) also reported no statistically significant differences between his matched groups of college students with good and poor articulation in their rail walking ability.

Mase (1946), in his study of causes of articulatory defects, also found no differences in rail walking ability as a measure of general motor coordination between a group of articulatory defective boys in grades five and six matched with normal speakers on the variables of age, I.Q., and socioeconomic status. Prins (1962) used tandem walking as his measure of gross motor control in a study of articulatory defective and normal speakers, but reported no statistically significant differences between the groups.

Coordination of eye, hands and arms. Several investigators restricted themselves to exploring measures of eye, hand and arm motor performance. Results of these studies are somewhat contradictory.

The rapidity of muscle movement requiring tapping behavior was explored by Carrell (1937). He reported that speech defective speakers with three or more sound substitutions tended to be significantly lower in their ability to tap a metal plate with a stylus than those speakers with normal speech. He did not find statistically significant differences between normal speakers and those children who had one or two phonetic transpositions. Carrell considered the differences statistically reliable, but actual differences were small.

Albright (1948) included two measures of tapping: one required tapping in time to an auditory pattern (synchrometer test) and the other required tapping a metal plate with a stylus, similar to Carrell's task. He reported that the synchrometer test indicated significant differences between the college students with good and poor articulation while the simple tapping task did not.

Maxwell (1953) found significant differences in hand tapping ability between boys with good and poor articulation, but at one age level only. Strother and Kriegman (1943) compared stutters and nonstutterers on a finger tapping task, but did not find significant differences between the two groups.

Tracing tasks also have been used to explore measures of hand and arm coordination, with inconsistent results. Carrell's study cited earlier indicated that the performance of the control group was superior to that of the group with sound substitution problems on a task requiring a pencil line to be drawn between the lines of a labyrinth. Children with a minimal number of phonetic transpositions performed better than the control group of normal speakers on the same task. When Carrell compared the total articulatory defective group with the controls, the controls were slightly superior in performance, but the differences were not statistically significant.

Maxwell (1953) used dotting, tracing, form board, and pellet and bottle tests for evaluating accuracy of eye-hand coordination. He was able to report reliable differences between speaker groups for only the tracing and pellet and bottle test with the non-preferred hand. Ball bouncing, considered by Maxwell as a measure of diadochokinetic rate for the hand, showed a reliable difference at only one age level.

Prins (1962) also tested performance of his subjects using the preferred hand with the pellet and bottle task. He reported a significant difference between articulatory defective speakers with phonemic substitution problems and normal speakers.

Assuming that speech requires certain kinesthetic cues, Carrell (1937) also explored kinesthesia in his study by using a tensiometer test. This test apparently required kinesthetic cues on the part of the subject in order to duplicate a standard "pull" on a plunger. He reported that the control group was superior in its performance when compared to the experimental group of articulatory defective speakers.

Albright (1948) used a hand drill with a counter attached to its shaft to measure ability to follow simple, fixed patterns at a maximum speed. Since the task required a smoothly repeated action to prevent the drill from "jamming," Albright considered the task to be a test of rhythm. Differences between the defective articulatory and normal speakers were statistically significant.

Hand steadiness was explored by both Albright and Maxwell. Albright measured the ability of a subject to insert a stylus into a hole with a small diameter without touching the sides of the hole. He found no significant differences between his subjects. Maxwell (1953), however, had his subjects perform a cube stacking task, and reported reliable differences between normal and defective speakers.

Bilto (1941) reported that approximately two-thirds of the speech defective subjects were inferior in their ability to bounce a ball for twenty seconds. Differences were reported without indications of their significance.

Albright (1948) tested writing rate as an additional measure of eye-hand coordination. His subjects wrote the first stanza of "Mary Had a Little Lamb." Differences between his college subjects with and without articulation problems were not significant.

<u>Laterality</u>. Johnson and House (1937) investigated laterality characteristics in severe articulatory cases and in normal speaking children by means of a simultaneous writing test. They also used an ocular test which required

the subject to look through a hole in a card held at arm's length. The authors reported that differences between the groups for the ocular task fell short of statistical significance. The control group showed a greater degree of right handedness on the simultaneous writing test. Differences between the groups for this test approached significance. Johnson and House concluded that handedness tended to be related to severe functional articulatory defectiveness.

Everhart (1953) also tested handedness in children in grades one through six in his study of various physical growth and development factors and the incidence of defective articulation. He included in his test battery a grip test measuring strength. Everhart concluded that measures of grip and handedness revealed no significant differences between children with and without articulation problems.

Relationships between non-oral, non-speech tasks and speech skills. Most of the studies cited earlier compared the performance of two or more groups of speakers distinguished by the presence or absence of speech disorders. Wellman, Case, Mengert, and Bradbury (1931) attempted to relate two measures of motor control to the number of sounds correctly articulated. The investigators found that results of a tracing test correlated with the total number of speech sounds correct at 0.67 and with the number of consonant blends correct at 0.65. They reported correlations of results of a perforation test with: the total number of sounds correct, 0.52; consonant elements correct, 0.53; and consonant blends correct, 0.40. These correlations do not denote a strong relationship between the measures of motor control and speech skill. Results of both the perforation test and the tracing test were correlated with age at 0.71 for the perforation test and 0.81 for the tracing test.

Although Carrell (1937) did not relate his tasks to speech skills, he submitted his data to multiple correlations for a subgroup of speakers with sound substitution problems. He correlated the variables of age, I.Q., auditory acuity, phonetic discrimination, tapping, tracing and the tensiometer test. Only four of the measures reached correlations of 0.50 or better. Age correlated with tapping (0.67) and with tracing (0.50). Tapping and tracing correlated with one another (0.65). Carrell concluded that the multiple _r_ is low enough to indicate that considerable variability is to be expected. He went on to explain that his study had not shown any single general factor invariably associated with sound substitution problems.

Relationships between non-oral, non-speech tasks and types of speech defects. Few studies have explored the performance of more than one type of speech defective speaker. However, two studies compared stutterers and subjects with articulatory problems.

Major (1940) investigated the performance of a group of stutterers and articulatory defective speakers and compared them to a group of normal speakers. Comparisons were based on a variety of motor skills. Speech defectives were inferior in their performance on thirteen tests of eye-hand coordination, tapping speed and rhythm. Results were not generalized as applying to all speech defectives because the experimental group included a large number of stutterers. Results were not considered to be conclusive for articulation cases.

Bilto (1941) reported that stutterers were about equal to articulation cases in their performance on the Brace Tests, slightly poorer on the Jump Reach Test, and, at some age levels, slightly better on measures of eye-hand coordination, i.e., ball bouncing. Significance of differences were not reported. Bilto concluded that no one measure differentiated between stutterers and articulatory defective speakers.

Summary of non-oral, non-speech tasks. On the basis of the available research, it must be concluded that non-oral, non-speech tasks have not been able to differentiate speech defective and normal speakers or subclasses of defective speakers. Previous research has not shown that articulatory defectives demonstrate a general retardation in motor skills (Winitz, 1969, p. 155). For every measure that designated significant differences between groups of normal and defective speakers, at least one study reported contradictory findings. Because of the large number of research studies surveyed and the complexity of their results, Tables 1 and 2 summarize the results of some of the studies which tested for significant differences between normal and defective speakers.

Table 1

Summary of Research Relating General Motor Coordination to Normal and Defective Speakers

Investigator	Test	Results Sign.	Results Nonsign.
Dickson (1962)	Oseretsky	X	
Jenkins and Lohr (1964)	Oseretsky	X	
Maxwell (1953)	Oseretsky (Portions)		X
Albright (1948)	Rail walking		X
Mase (1946)	Rail walking		X
Prins (1962)	Tandem walking		X

Differences in methodology probably account for some of the inconsistent results. For example, some studies measured rate or speed of a task while others evaluated accuracy. Some of the studies did not control variables of age, sex, severity of problems, or types of speech disorders. Rigorous statistical procedures were not used by every investigator. Intrasubject and group variability of performance may have accounted for some of the contradictory results. Jenkins and Lohr (1964) noted that motor quotients suggested wide variability and Bilto (1941) reported that one third of his speech defective subjects did as well as his normal speakers on the measures he used in his study. Measures of temporal reliability were not described in the studies.

Table 2

Summary of Research Relating Eye-Hand-Arm Coordination to Normal and Defective Speakers

Investigator	Test	Results Sign.	Results Nonsign.
Carrell (1937)	Tapping		
	subgroup	X	
	total group		X
	Tracing		
	subgroup	X	
	total group		X
	Tensiometer	X	
Albright (1948)	Simple tapping		X
	Synchrometer	X	
	Hand drill (rhythm)	X	
	Stylus task		X
	Writing rate		X
Maxwell (1953)	Hand tapping	X (one age)	
	Dotting		X
	Tracing	X	
	Form board		X
	Pellet and bottle	X	
	Ball bouncing	X (one age)	
	Cube stacking	X	
Strother and Kriegman (1943)	Finger tapping		X
Prins (1962)	Pellet and bottle	X	
Johnson and House (1937)	Simultaneous writing	X	
	Ocular test		X
Everhart (1953)	Grip test		X

Some investigators (Dickson, 1962; Jenkins and Lohr, 1964; and Bilto, 1941) used a battery of tests and found significant differences more frequently than did those studies which used a single measure of motor ability. It may be that general motor ability is more important than ability on any specific task of motor skill.

Oral, Non-speech Tasks

Oral, non-speech tasks concern movements of the articulators without speech. Movements of the jaw, lips and tongue have been tested to see whether meaningful differences can be found between the performances of normal and defective speakers. Rate, the number of times a task is completed in a unit of time, is usually the only criterion measure employed. Accuracy of performance or strength measures have been employed by some investigators as criterion measures.

Jaw movement. Jenkins (1941), Pettit (1939) and Schlanger (1939) established normative date for opening and closing the jaw. Schlanger's work included ages seven, eight and nine; Pettit studied ages 12 through 17; and Jenkins reported on ages 10, 11, 18, 19, 20 and over.

Jenkins concluded in his summary of the three studies, that diadochokinetic rate of the jaw tends to increase from age 7 to 18, although rate did not correlate closely with age. After age 17, there appears to be no correlation of rate with age.

In one of the earlier studies of motor ability, West (1929) investigated differences in diadochokinetic movements between 25 stutterers and 39 nonstutterers. He measured speeds of jaw opening and closing; raising and lowering brows; and finger tapping. West found that normal speakers were superior in their speeds, although 11 of the 39 stutterers overlapped normals in their rates.

In contrast to West, several investigators found no significant differences between speaker groups on measures of jaw movement. Albright (1948) employed a teeth-click test in his battery and reported no significant differences in the performances of college students with good and poor articulation. He noted, however, that due to an electrical counter's failure to record all clicks, the results were somewhat unreliable.

Mase (1946) was not able to find any significant differences in performances of jaw mobility in his study. Fairbanks and Spriestersbach (1950) also found no significant differences in vertical movement of the mandible in their study of college speakers with superior and inferior articulation. Strother and Kriegman (1943), although they found that stutterers performed at a slightly faster rate than nonstutterers, reported differences as nonsignificant.

Bitonti (1969) compared one group of children who had responded to therapy with another group who had made little progress during the previous year. He compared tongue protrusion, tongue lateralization, jaw movement, and repetitions of speech syllables with no significant differences noted between the two groups. A correlation matrix performed for each group revealed that jaw movements were significantly related with "puh" (0.05); "tuh" (0.05); and "kuh" (0.01) for each of the groups.

Lip movement. Most studies of lip movement have not disclosed significant differences between normal and defective speakers. Strother and Kriegman (1943) reported that rates of stutterers were slightly superior to non-stutterers, but these differences did not achieve statistical significance. Fairbanks and Spriestersbach (1950) found significant differences in their study of repetitive measures of approximating the lips only for male subjects.

Tongue movement. Investigations of tongue measures explored not only rate of movement but also force of movement. Results tend to be inconclusive with regard to specific speech disorders.

Palmer and Osborn (1940) evaluated tongue pressure with a mercury manometer for subjects aged 6 to 46 years. Differences in tongue pressure between speech defective and normal speakers were significant, with normal speakers exhibiting greater strength. Differences in performance were not significant for sexes. In contrast to the above study, Fairbanks and Bebout (1950) found no significant difference on measures of tongue force between their college subjects, with and without speech disorders. When the investigators explored the variables of sex and performance, they found a significant difference in favor of the males; however, the differences were small.

Measures of tongue dimensions and mobility generally have yielded negative results. When Fairbanks and Bebout in the study cited earlier explored length of tongue protrusion, length of tongue tip, and percentage of error in duplicating a tongue position in their study of superior and inferior articulatory speakers, the reported differences failed to reach significance. In a companion study, Fairbanks and Spriestersbach (1950) reported that measures of tongue protrusion indicated differences that were significant for only the superior male speakers. Differences in performance for tongue-alveolar movements did not achieve significance for any of the subjects.

Mase's (1946) test battery included tongue protrusion tasks and speed of lateral movements of the tongue. Mase found no significant differences in his comparative study of normal and defective speakers.

Matthews and Byrne (1953) tested the hypothesis that children with cleft palates have inferior tongue flexibility when compared with noncleft children. Their test battery included measures of movement of the tongue in and out of the mouth; touching the tongue tip to upper and lower lips; and rotating the tongue around the lips, both inside and outside the mouth. The authors reported no significant differences between the cleft and noncleft children on measures of tongue movement.

In the study cited earlier, Bitonti found no significant differences in tongue protrusion or tongue lateralization between two groups of speech defective children. A correlation matrix for children who had progressed in therapy revealed that tongue lateralization related to "puh" (0.05), "tuh" (0.05), "kuh" (0.01), and with the jaw movement (0.01). Lateralization measures for the group who had not progressed related as follows: "tuh" (0.01); "kuh" (0.01); "puhtuhkuh" (0.05).

<u>Oral, non-speech tasks related to speech skills</u>. Two of the studies compared the performance of the subjects during oral, non-speech tasks with performances during speech tasks or with measures of speech defectiveness. Since some of the findings of these studies pertain to tasks other than non-speech tasks, only portions of the results will be considered in this section.

Heltman and Peacher's (1943) investigation of spastic paralytics included a number of diadochokinetic measures: jaw movements; lip movements with and without voice; lifting of the tongue to the alveolar ridge with and without voice; finger tapping; and pronation and supination of the forearms. The authors reported that diadochokinetic rates were below those found in nonspastics, but that rates increased with age increases ($r = 0.69$, which was statistically significant). The study also found that rates for tongue and lip movements with voice were significantly faster than the same movements without voice. When age was partialed out, rates correlated - 0.76 with the number of speech errors. The correlation was highly significant, and indicated that the greater the rate of diadochokinesis, the fewer the number of articulatory errors.

Hixon and Hardy (1964) attempted to investigate the relationships among speech defectiveness, rate of repetition of certain consonant-vowel syllables, and rates of repetitive non-speech movements of the speech articulators in 25 spastic and 25 athetoid children. The oral, non-speech tasks included opening and closing the lips, retracting and rounding the lips, raising the tongue to the alveolar ridge and lowering it, moving the tongue from one corner of the mouth to the other and opening and closing the jaw. Hixon and Hardy found that the mean rates of the speech movements tended to be much faster than the mean rates for the non-speech tasks. Furthermore, only one non-speech task (lateralization of the tongue) achieved a correlation of - 0.50 with the measure of speech defectiveness. The weakest predictor of speech defectiveness was the task of raising the tongue to the alveolar ridge (-0.28). The non-speech tasks could account for only 37% of the variability of ratings of speech defectiveness while speech tasks accounted for 58% of the variability. All variables in the study accounted for only 64% of the variability of the speech defectiveness measure. The non-speech tasks did not exhibit strong relationships among themselves nor with the speech tasks.

La Pointe (1969) used isolated non-speech movements and sequences of the same movements in a study of normal speakers and a group of subjects with cerebral cortex damage. His measures included protruding and retracting the tongue; lateral tongue movements; touching the upper and lower lips with the tongue; circular licking of the lips; opening and closing the jaw; clicking the teeth; biting the lower lip; protruding the lips; spreading the lips with and without the teeth being visible; puffing the cheeks; whistling and coughing (non-reflexively). He found significant differences at the 0.01 level between his subjects. He concluded that brain-injured subjects with articulatory deviations have more difficulty producing both isolated and sequential oral movements than do subjects with no known pathology. He was not able to relate the disordered isolated movements to types of articulatory deviations, and reported that some of his pathological subjects passed all motor tasks. La Pointe's results should be viewed with caution since his pathological population included a large number of subjects with facial and lingual paralysis.

Relationships between oral, non-speech tasks and types of defects. Only one of the investigations explored differences in performance among types of speech defects, and that was Palmer and Osborn's study (1940) of tongue pressure.

Performances of stutterers and subjects with articulatory deviations were compared with the performances of subjects in a control group. Differences between stutterers and the control group were not significant. Differences between the controls and defective articulation group achieved significance. Palmer and Osborn noted that their experimental group included subjects characterized by frequent occurrences of malnutrition and febrile diseases, conditions which could affect measures of strength.

Summary of oral, non-speech tasks. On the basis of the research available, investigations into movements of the oral structures apart from speech activities have not demonstrated significant differences between groups of speakers. Results are contradictory for jaw mobility for stutterers and nonstutterers; differences between articulation cases and normal speakers have not been significant. Measures of lip and tongue mobility generally do not distinguish between normal and defective speakers. Tongue pressure studies have presented contradictory results. Table 3 summarizes some of the results of the studies which tested for significant differences between normal and defective speakers.

The low correlations between results obtained for oral, non-speech tasks and speech defectiveness in the studies reported thus far, suggest that there is only a limited relationship between motor ability required to manipulate the

Table 3

Summary of Research of Oral, Non-Speech Tasks to Normal and Defective Speakers

Investigator	Test	Results Sign.	Nonsign.
Albright (1948)	Teeth click		X
Mase (1946)	Jaw mobility		X
	Tongue protrusion		X
	Lateral tongue movement		X
Fairbanks and Spriestersbach (1950)	Mandible		X
	Lip	X-males	
	Tongue protrusion	X-males	
	Tongue tip		X
Strother and Kriegman (1943)	Mandible		X
	Lip		X
Bitonti (1969)	Tongue protrusion		X
	Tongue lateralization		X
	Jaw movement		X
Palmer and Osborn (1940)	Tongue force	X	
Fairbanks and Bebout (1950)	Tongue force		X
	Tongue protrusion		X
	Tongue tip length		X
	Tongue position		X
Matthews and Byrne (1953)	Tongue mobility		X
La Pointe (1969)	Tongue protrusion	X	
	Tongue lateralization	X	
	Touching lips	X	
	Opening jaw	X	
	Teeth click	X	
	Biting lip	X	
	Protruding lips	X	
	Puffing cheeks	X	
	Whistling	X	
	Coughing	X	

structures of the oral mechanism and the motor skills required to manipulate and modify the air stream for speech purposes. It may be, as Hixon and Hardy (1964) suggest, that motor behavior during non-speech activities uses neuromuscular operations that are not the same as the operations required for functioning of the same organs during speech activities.

Whether Hixon and Hardy are correct in their assumption, does not change the fact that oral, non-speech tasks as described in the literature do not distinguish between normal and defective speakers or among subclasses of speech defectives.

Speech Tasks

The third type of task reported in the literature employs speech. In this type of task, diadochokinetic rates of the articulators and vocal folds are measured during the production of syllables. Findings are difficult to compare, since some of the studies are normative, some are comparative studies of defective and normal speakers and other studies are descriptive studies of speech characteristics of a particular subclass of defective speakers. Other studies relate diadochokinesis to variables other than defective speech. Since the findings related to speech tasks tend to demonstrate more differences between speech defective and normal speakers than do non-oral, non-speech or oral, non-speech tasks, the results of speech task investigations will be considered in more detail than has been given to the other types of tasks.

Single syllables. Most of the studies, regardless of the purpose of the investigation, employed single syllables. Many of the studies have used the same stimulus items.

Blomquist (1950) provided normative data for children aged nine through eleven years for /pə/, /tə/, /kə/, and /pətəkə/. Irwin and Becklund (1953) established normative data for children aged six, seven, nine, eleven, thirteen and fifteen years for /pə/, /tə/, and /kə/. Lundeen (1950) studied rates for adults and in addition to /pə/, /tə/, and /kə/, he provided data for /bə/, /də/, /gə/, /fə/, /və/, /sə/, and /zə/.

Comparative studies of speech defective and normal speakers relative to their performance on monosyllabic tasks have yielded inconclusive results. Maxwell (1953) and Ewanowski (1964) did not find significant differences on repetitive productions of /pə/, /tə/, or /kə/ between speech defective and normal speakers. Strother and Kriegman (1943) reported no significant differences in their study of /t/.

Prins (1962) found significant differences (0.05) between articulatory defective and normal speakers in favor of normal speakers for /kʌ/. He further noted that /tʌ/ and /kʌ/ differentiate between some of the subgroups of articulatory defective speakers.

Matthews and Byrne (1953) found differences for /tɑ/, /kɑ/, and /θɑ/ between cleft and noncleft speakers in favor of the noncleft speakers. Albright (1948) reported significant differences between college students with superior and inferior articulation in favor of the speakers with superior articulation for /lɑ/ and /mu/.

Maxwell (1953), in his study of boys with and without articulation problems, found that measures for /lɑ/ were significant for some ages. Canter (1965) reported that /bə/ , /də/, /gə/, and /hɑ/ were significant measures in his investigation of speech characteristics of Parkinson patients. Hixon and Hardy (1964) indicated that /mʌ/, /dʌ/ and /gʌ/ correlated - 0.70 or better with measures of speech defectiveness in their study of cerebral palsied subjects.

On the basis of research findings up to the present time, /pə/ does not seem to discriminate between speech defective and normal speakers and the findings are inconclusive for /tə/ and /kə/ . Use of the syllables of /bə/, /də/, /gə/, /θɑ/, /hɑ/, /lɑ/, and /mu/ or /mɑ/ appear to result in some significant differences between speakers groups. With two exceptions, there are no normative studies for these items. Lundeen (1950) provided normative data for adults speaking /bə/, /də/, and /gə/ . Maxwell (1953) compiled normative data for /pɑ/, /tɑ/, /kɑ/, /lɑ/, and /pɑtɑkɑ/ for boys seven, eight and nine years of age.

Multiple Syllables. Although only a few of the comparative and normative studies include data regarding polysyllabic utterances, these measures tend to show significant differences between speech defective and normal speakers.

The sequence of /pʌtʌ/ has been reported by Prins (1962) as differentiating between normal and articulatory defective speakers at the 0.01 level of significance.

Fletcher (1968) compared speakers with limited lingual freedom due to a short lingual frenulum and speakers with greater freedom. He used /tʌ/, /lʌ/, /pʌtə/, /tʌkə/, and /pʌtəkə/ as test items. He reported that diadochokinetic rates of syllable repetitions were slower for subjects with limited freedom, but the differences were significant only for /pʌtə/ and /tʌkə/ . Albright (1948) also indicated that /tʌkʌ/ differentiated normal and articulatory defective speakers.

The sequence /pʌtʌkʌ/, according to Maxwell (1953) and Prins (1962), differentiated normal and defective speakers. Ptacek, Sander, Maloney, and Jackson (1966), in their study of young and geriatric speakers, reported that results for /pʌtʌkʌ/ were significantly different between groups when single syllable repetitions were not. However, they indicated that motivation may have been a factor in the performance of the geriatric subjects.

Aten and Davis (1968) used a series of nonverbal and verbal tests in a study of children with minimal cerebral dysfunction. Subjects were required to repeat the syllables /pʌ/, /lʌ/, /gʌ/, /dʌ/, /kʌ/, /mʌ/, and /pafataka/. The single syllables did not reveal significant differences between children with and without known cerebral dysfunction. Differences for the performances of the polysyllabic sequence were significant at the 0.01 level. Aten and Davis suggest that the ability to orally sequence the syllables /pafataka/ is a sensitive measure of oral phonetic skill and stimulability. Although Aten and Davis use the syllables for different purposes than the other studies of diadochokinesis, their study indicates that the sequence was meaningful when single syllables were not.

Prins analyzed repetitions of polysyllabic sequences among his groups of articulatory defective speakers. He reported that /pʌtʌ/ and /pʌtʌkʌ/ were significantly different among his groups characterized by lisping, omissions and phonemic substitutions.

Longer passages. Evaluation of the rate of performance on tasks characterized by words occurring in sequence technically is not part of diadochokinetic measurement, since the criterion of cyclical, repetitive movements cannot be achieved. However, two studies explored rate of performance on tasks that required recitation of a rhyme or reading of a passage. Albright (1948) found that recitation rate was significantly different between normal and articulatory defective speakers. Marge

(1964), however, reported that loading of the reading task on the factor of speech motor skill was minimal, and he concluded that the reading task tapped skills other than articulation speed.

Length of elicited sample. Maxwell (1953) used trials of two seconds each; Strother and Kriegman (1943) used three second trials; Matthews and Byrne (1953), Irwin and Becklund (1953) and Bitonti (1969) used five second trials. Ptacek et al (1966) and Lundeen (1950) used seven second trials, but analyzed only the middle five seconds. Hixon and Hardy (1964) and Heltman and Peacher (1943) each used ten second trials. Ewanowski (1964) and Blomquist (1950) did not specify the length of sample trial in their studies. Ewanowski asked for maximum effort during maximum exhalation while Blomquist requested that her subjects perform three trials. She apparently analyzed only 2.35 seconds from each trial. Canter (1965) used a 30 second time period, but analyzed his data in five second segments. The wide range in length of elicited sample may have accounted in part for the variability of results in the literature.

Unit measure computed. Most of the researchers computed the mean number of single syllable tasks per second as a criterion measure. However, Marge (1964) and Prins (1962) recorded the number of single syllable repetitions in five seconds and Hixon and Hardy (1964) recorded the number of repetitions in ten seconds. Irwin and Becklund (1953) reported the mean rate for the single syllable items, using the maximum rate for each subject for each test item as the basis for computations. Bitonti (1969) used the mean number of sounds in three trials of five seconds each for his score.

Blomquist (1950) and Ptacek et al (1966) apparently computed their measures of /pʌtʌkʌ/ on a syllable per time unit basis while Prins (1962) and Hixon and Hardy computed the number of times all three syllables as a unit were satisfactorily completed in the time period.

Computation of the reported measure also differed in respect to whether the mean was a group mean computed from a single trial by each subject (Lundeen, 1950; Prins, 1962; Marge, 1964), the means of repeated trials for each subject (Blomquist, 1950; Matthews and Byrne, 1953; Hixon and Hardy, 1964; Bitonti, 1969), or the trial with the maximum rate (Irwin and Becklund, 1953). These variations in computation hinder comparisons between studies.

Nature of trial. Many of the researchers (Strother and Kriegman, 1943; Blomquist, 1950; Irwin and Becklund, 1953; Hixon and Hardy, 1964; Ewanowski, 1964; and Bitonti, 1969) used three trials for acquiring measurements of performance. Matthews and Byrne (1953) based their report on four trials. Others (Heltman and Peacher, 1943; Lundeen, 1950; Prins, 1962; and Canter, 1965) appear to have acquired their measurements from one trial only.

Not all studies were consistent in reporting practice trials nor the nature of controls related to the practice period. However, procedures varied widely. Lundeen used two periods of three seconds each; Blomquist and Matthews and Byrne gave the children in their studies a practice period of indeterminate length. Irwin and Becklund and Ewanowski used several practice periods of unknown length. Hixon and Hardy indicate that the tasks were demonstrated prior to performance. It is interesting to note that most studies describing practice trials had individual practice periods; Blomquist, however, had her subjects practice as a group.

Normative data. Much of the research has provided normative data for the single syllables of /pə/, /tə/, and /kə/. Some of the other single syllables that appear to show significant differences between groups of speakers, /mɑ/, /lɑ/, /θɑ/, /bə/, /də/, and /gə/, are not well supported by normative data.

With the exception of Blomquist's study (1950), normative data are not available for syllable sequences. However, a number of researchers (Albright, 1948; Prins, 1962; Maxwell, 1953; Ptacek et al, 1966) indicate that sequences show significant differences between speakers when single syllables do not.

Criterion measures and variability. Ewanowski (1964) included both rate and duration as criterion measures in a study of oral motor skills in normal speakers and subjects with Parkinson's Disease. Significant differences in duration were found in his study although differences in rate were not significant. Other investigators have not used duration as a criterion measure.

Variability among subjects, according to Blomquist (1950) and Lundeen (1950) is not significant. Blomquist also examined variability among trials for her subjects and reported that the three trials were not significantly different. Irwin and Becklund (1953) and Ewanowski (1964) reported that variability in performance among subclasses of speakers is not significant. Irwin and Becklund suggest that variability of rate change within age levels may exceed the rate of change between age levels. In a study of temporal reliability in articulatory testing, Winitz (1963) suggested that intrasubject variability may be a function of the task, methodology and time.

West (1929), Bilto (1941), Canter (1965) and La Pointe (1969) reported that some of their defective speakers performed as well or better than did some control subjects during tests of diadochokinesis. Their results in general show a relatively wide range of variability and areas of overlap between normal and defective speakers.

Few investigators have explored variability of their measures, and the studies which have done so, have been concerned with single syllable performance. Variability for multiple syllable sequences has received limited attention from Blomquist.

Voicing. It is interesting to note that much of the research has been content to explore the unvoiced plosives /p/, /t/, /k/ in a consonant-vowel combination. Heltman and Peacher (1943) report that diadochokinetic rates of the oral mechanism when accompanied by voicing were significantly faster than rates for the same structure without voice. These results suggest that voicing of the consonant may be a facilitating factor in speed tests. Lundeen (1950) compared voiced and unvoiced cognates in his study and reported significant differences. Hixon and Hardy's (1964) experimental design does not permit a direct comparison among their speech tasks. They used single syllables of /mʌ/, /dʌ/, and /gʌ/ and the sequence of /pʌtʌkʌ/ . The authors indicated that their subjects had faster rates for the voiced than for the unvoiced consonant syllables. They concluded that unvoiced consonant syllables may be more difficult to repeat over time, at least for the cerebral palsied child.

Manner of formation and place of articulation. Manner of formation has received comparatively little attention. Lundeen (1950) examined some fricatives as well as plosives and found that fricatives are produced at a slower rate. Lundeen's data suggest that location of the sound (place of articulation) is related to the speed of production, since in his data rates of bilabial plosives exceeded rates of velar plosives. Canter (1965), Hixon and Hardy (1964) and Prins (1962) also found that velar measures were slower than rates for sounds produced from other places of articulation.

Studies which examined the relationship between place of articulation and defective speech indicate that rates for velar syllables reveal significant differences between normal and defective speakers. Canter (1965) found that tongue tip and back of tongue movements correlated (Spearman R = 0.86) with a judgment of clarity of articulation in his Parkinson's patients. Hixon and Hardy reported that performance of /gʌ/ was the best single predictor of speech defectiveness in their study.

Canter (1965) and Bitonti (1969) examined relationships among places of articulation. Canter reported that tongue tip and back of tongue movements were highly correlated (Spearman R = 0.97). Lip movements were related to tongue tip movements (R = 0.75) and to back of tongue movements (R = 0.79).

In a correlation matrix constructed for each of the two articulatory defective groups, Bitonti found significant differences between "puh" and "tuh," "puh" and "kuh," "tuh" and "kuh," "tuh" and "puhtuhkuh," "kuh" and "puhtuhkuh." The last two comparisons were not significantly different for the group that had not progressed in therapy.

Comparatively little attention has been given to the employment of nasal consonants in the measurement of oral motor activity. Canter (1965) has reported limited data for /mə/ and Maxwell (1953) included /mu/ in his battery of test items.

Summary. In general, studies which use speech tasks in the measurement of oral motor function demonstrate marked differences in their design and in their reported results. Table 4 presents the results from studies which tested significant differences between normal and defective speakers. Most investigators examined only single CV syllables and, in the main, employed plosive consonants only.

Comparisons among studies have been hampered by variations such as the length of the elicited sample, the criterion measure and differences in the speech tasks. In most instances, diadochokinetic rates for speech tasks have shown a higher correlation with speech skills than have non-oral or oral, non-speech tasks.

SUBJECTS

Age

The age span incorporated in the research is rather extensive. Irwin and Becklund (1953) explored diadochokinesis in children as young as six years; Ptacek et al (1966) and Shanks (1966) explored rates in some individuals aged sixty and over. Although most investigators used age

Table 4

Summary of Research Relating Speech Tasks to Normal and Defective Speakers

Investigator	Test	Results Sign.	Results Nonsign.
Maxwell (1953)	/pʌ/ /tʌ/ /kʌ/		X
	/lɑ/	X some ages	
	/pʌtʌkʌ/	X	
Ewanowski (1964)	/pə/ /tə/ /kə/		X
Strother and Kriegman (1943)	/t/		X
Prins (1962)	/tʌ/	X some groups	
	/kʌ/	X	
	/pʌtʌ/	X	
	/pʌtʌkʌ/	X	
Matthews and Byrne (1953)	/tɑ/ /kɑ/ /θɑ/	X	
Canter (1965)	/bə/ /də/	X	
	/gə/ /hɑ/	X	
Fletcher (1968)	/tʌ/ /lʌ/		X
	/pʌtə/	X	
	/tʌkə/	X	
	/pʌtəkə/		X
Albright (1948)	/tʌkʌ/	X	
	/lɑ/ /mu/	X	
	rate of recitation	X	
Ptacek <u>et al</u> (1966)	/pʌ/ /tʌ/ /kʌ/		X
	/pʌtʌkʌ/	X	
Aten and Davis (1968)	/pʌ/ /lʌ/		X
	/gʌ/ /dʌ/		X
	/kʌ/ /mʌ/		X
	/pɑfɑtɑkɑ/	X	

as part of their design, few explored the relationship between age and motor skills. For the most part, studies indicate that rates increase with increases in age, at least until adulthood. Irwin and Becklund, although substantiating that rate increases with age increases, suggest that these changes are quite small. Jenkins (1941) did not find reliable correlations between rate and age. Blomquist (1950) found that differences for some measures between ages may be related in part to differences in sex. Irwin and Becklund observed various patterns of superior performance between sexes at different ages. Although the research indicates that there are relationships between rates of performances and age, the literature has not been able to identify specific measures which indicate differences between normal and defective speakers at all age levels.

Relationships between age and diadochokinesis once adulthood has been achieved were explored by Ptacek and his associates and by Shanks. Ptacek <u>et al</u> found that his geriatric subjects had lower rates than his control groups, (significant at the 0.01 level) for /pʌ/, /tʌ/, /kʌ/, /ʌ/, and /pʌtʌkʌ/ . Shanks found no age-related differences between groups for similar tasks.

<u>Sex</u>

Not all of the studies measured diadochokinetic rates of both males and females. Those investigators who examined rate did not always determine rate differences between males and females, and those who did make such comparisons report conflicting results.

Lundeen (1950) and West (1929) noted that males were slightly superior in their rates. Jenkins (1941) also reported that male children, when rates were adjusted to compensate for more rapid female physical development, exceeded the rates of female children. Although Irwin and Becklund (1953) did not submit their data to statistical analysis, they observed that younger boys were slower than younger girls and that older boys were faster than older girls in diadochokinetic rates. Fairbanks and his associates (1950a, 1950b) found males somewhat superior on some tasks, but in general, differences were not significant. Blomquist (1950) found that differences between sexes were not significant when age was held constant.

Speech Status

Many of the studies of diadochokinesis discussed earlier compared speech defective and normal speakers. A general conclusion, based on the literature, is that speech defectives tend to be inferior in their productions of articulatory diadochokinetic tasks. Subgroups within the population of speech defectives may perform differently (Bilto, 1941; Prins, 1962).

Few of the investigators related rates of performance on specific tasks to general speech adequacy or characteristics of speech. Marge (1964) attempted to identify the factors of oral communication skills in the older child. He submitted forty variables employed in his study of oral communication skills to factor analysis. The analysis revealed seven factors, including a factor called "motor skill in speaking." High loadings on this factor consisted of the speed of total articulation, i.e., total score of pa, ta, ka, 0.96; ka, 0.88; ta, 0.87; and pa, 0.83. Speed of oral reading loaded only 0.16, indicating that variables other than motor skill alone were active. Marge's data indicate that motor skills are related to speech performance in general, and that diadochokinetic tasks have a strong relationship to motor function.

METHODOLOGY

Few of the studies of oral motor skills have employed the same procedures and the same instrumentation. Some of the variations in procedures have been considered in the discussion of tasks and subjects.

Another source of variation concerns differences in instructions. Ewanowski (1964) believed that his instructions and frequent motivation of subjects were primarily responsible for his findings which were contrary to Canter's results.

Instrumentation employed for recording subjects' responses included such items as electronomes and stop watches, mechanically actuated recording tambours and graphic read-outs from electro-acoustical devices.

Instrumentation has not been clearly described in every case. However, mechanically-actuated devices, such as the type used by Strother and Kriegman (1943) may interfere with movement of the structures being explored and thus affect the measure obtained. The designs that measured sounds rather than movements tended to minimize this type of interference.

SUMMARY

The variations in tasks, subjects and procedures discussed in this chapter probably contribute much to the inconclusive and contradictory findings in the literature. No one task seems able, at this time, to differentiate between behavior of the normal and defective speaker, although some studies suggest that velar and tongue-tip sounds and polysyllabic sequences are more discriminative.

The lack of efficiency and precision and limited reliability of measures may also contribute to the inconclusive results (Sommers, 1967). Greater control of the wide range of related variables in the design of a diadochokinetic study would perhaps yield more definitive measures. Locke(1968) and Winitz (1969) recommend multiple factor research. It is interesting to note that some of the more recent studies (Canter, Ptacek et al, Ewanowski, Hixon and Hardy) have explored multiple variables, but normative studies have not.

The review of the literature makes it clear that motor articulatory skill is an important requisite for speaking skill. The literature also suggests that more definitive information is needed relative to the performance of normal speakers during motor articulatory activity and the variables influencing their performance.

CHAPTER III

METHODOLOGY

SUBJECTS

Thirty subjects, 15 males and 15 females, were selected randomly from study hall students aged 16.5 years to 17.5 years enrolled in a Baton Rouge, Louisiana, public high school.

Criteria for selection included:

1. No known history of referral for speech therapy by high school faculty or failure in speech screenings by the speech therapist.

2. Assessment of speech competency: No observable speech defect noted by the investigator during an informal conversation with the investigator. Students described their interests and hobbies, summer plans and school subjects and responded to questions regarding speech and/or hearing difficulties, lung diseases, breathing difficulties, muscle weakness, frequent colds, or any health problems that

might interfere with performance. If no problems were detected during the interview which prohibited participation, and if the student consented to be a subject, the hearing test followed. Of the students interviewed, only two were not included in the study. One was eliminated because of a hearing problem and the other student was unwilling to be a subject.

3. Adequate hearing as ascertained by an audiometric pure-tone screening test of 500, 1000, 2000, 4000, and 8000 Hz at 25 dB (ISO 1964) with no more than one failure permitted at a single frequency in either ear. A Maico portable audiometer, Model 2B, calibrated to ISO 1964 standards, was used for the hearing test. Calibration of the audiometer was verified prior to the screening tests and again following the testing.

4. No known history of neuromuscular impairment.

5. No known upper respiratory system involvement at the time of testing.

6. Average intelligence according to the records of school guidance counselors.

7. Willingness to participate in the study, as indicated by the potential subjects

during the personal interview which was a part of the overall screening process.

During the interview, the following information was given to the potential subjects:

> One cause for speech problems is poor muscle performance. One way of determining if poor motor skills contribute to a speech problem is to have a person rapidly repeat nonsense syllables, /pʌ, pʌ, pʌ, pʌ, pʌ/. Unfortunately at this time, speech clinicians do not have very satisfactory information about what normal speakers do to make judgments about muscle activity in people with speech problems. Your participation in the study will help to determine what normal speakers do when asked to say nonsense syllables as rapidly as they can for as long as they can.

In order to insure maximum cooperation from those who qualified, three ideas were stressed: participants were viewed as being normal speakers; there would be no failure involved even though some tasks are more difficult than others to perform; participants were providing a valuable service to the investigator and, ultimately, to those who help people with speech problems.

It is possible that the above instructions had some motivational as well as explanatory value to the subjects who agreed to participate.

TEST ITEMS

Forty-five items, consisting of 15 single syllables, 15 two syllable sequences, and 15 three syllable sequences, comprise the test items in the study. The 45 items represent various places of articulation, manners of formation, voicing, length of item and interaction between place of articulation and manner of formation. A task is defined operationally in this study as repetitions of one of the kinds of test items. The basic tasks assigned to the subjects in the present study were to repeat the items described above as accurately, as fast and for as long as possible after a maximum inhalation.

Selection of Single Syllable Items

One of the primary concerns in item selection was the phonemic composition of the item. Because the purposes of the study focus on factors usually associated with consonants, i.e., place of articulation and manner of formation, only one vowel is used in the study to facilitate data analysis. The mid-central vowel /ʌ/ was selected because: it has been used in other studies, making feasible comparisons between previous research and this study; and, it combines readily with the consonants selected for the study.

Selection of the consonant portion of the syllable was based on the criteria of place of articulation, manner of formation and voicing. Selection was also influenced by the type of syllable, i.e., CV or VC, to be used in the study and by the frequency of occurrence of phonemes in American English speech.

Place of articulation. It is important to select phonemes according to place of articulation in order to explore differences in rate and duration of syllable repetitions as a function of articulatory behavior and its interaction with types of sounds according to manner of formation. Consequently, places of articulation selected for this study include labial, labio-dental, lingua-dental, lingua-alveolar, lingua-palatal, and lingua-velar. These categories were selected to permit exploration of a wide range of articulatory activity and data and to enable comparisons with previous studies.

Manner of formation. Three types of sounds were chosen for the study, classified according to manner of formation: plosives, fricatives and nasals. These categories were selected because: they have some places of articulation in common, e.g., labial and lingua-alveolar, facilitating comparisons; a pilot study using the test items and instrumentation indicated that syllables with consonants in these categories could be recorded and analyzed readily; they permit comparisons with previous research.

Voicing. Voiced and unvoiced cognates were selected in order to explore the effects of voicing upon rate and duration of performance. These cognates were restricted to the plosive and fricative phonemes, since nasals do not have a voiceless counterpart in normal American English speech.

Type of syllable. All test items consist of consonant-vowel (CV)syllables. This particular pattern was chosen in part because it is a common pattern in American English speech (Fletcher, 1953, p. 94). A second reason for selecting this pattern related to the necessity of limiting the scope of the study. Students could be excused only for one hour to participate in the study, corresponding to the length of the study hall period. Since the single syllables were also repeated in the two syllable sequences and the three syllable sequences, the number of single items had to be restricted. The CV pattern reduced the number of possible syllables and permitted comparisons with previous studies.

Frequency of occurrence. Selection of the test items was influenced also by the frequency with which phonemes appear in American English speech in the CV pattern. Since /ŋ/ does not occur as an initial consonant in a syllable, /ŋʌ/ was deleted as a test item. The relatively infrequent occurrence of /ʒ/ in American English speech led to elimination of /ʒʌ/ as a test item (Fletcher, 1953, pp. 95, 96).

Table 5 presents the 15 single syllables selected for the study arranged according to place of articulation, manner of formation and voicing.

Selection of Multiple Syllable Sequences

One of the factors explored in the study is the effect

Table 5

Single Syllable Stimulus Items According to Place of Articulation, Manner of Formation, and Voicing

Place of Articulation	Plosives v*	Plosives vl	Fricatives v	Fricatives vl	Nasals v	Nasals vl
labial	bʌ	pʌ	--	--	mʌ	--
labio-dental	--	--	vʌ	fʌ	--	--
lingua-dental	--	--	ðʌ	θʌ	--	--
lingua-alveolar	dʌ	tʌ	zʌ	sʌ	nʌ	--
lingua-palatal	--	--	--	ʃʌ	--	--
lingua-velar	gʌ	kʌ	--	--	--	--

* Refers to consonant element in syllable: v = voiced; vl = voiceless

of length of test item upon rate and duration of performance. Sequences comprised of two and three syllables were constructed using the same consonants and vowels employed in the first fifteen items.

A strict permutation of the syllables tested in the present study would produce a massive number of syllable sequences. Therefore, it was necessary to delimit the scope of this portion of the study by the factor of shift from an anterior place to a more posterior place of articulation, e.g., /pʌtʌkʌ/. This pattern of anterior to posterior shift in place of articulation both restricts the number of possible combinations and permits comparisons with previous studies. Also, it enables the investigator to explore effects of length of stimulus upon rate and duration of performance.

Assignment of place of articulation to a particular category was based on the relationship between phonemes as shown in Table 6. For example, the labial /p/ is produced anteriorly to the lingua-alveolar /t/ and to the lingua-velar /k/. Because /t/ is neither the most anterior nor the most posterior plosive, /t/ is designated as a medial plosive. Likewise, /s/ is not produced as far forward in the mouth as /f/ nor as far back as /ʃ/ and therefore, for the purposes of the present study, /s/ is classified as a medial fricative. For similar reasons, the anterior category includes labial, labio-dental and lingua-dental phonemes. The posterior category includes

Table 6

Assigned Position of Consonants on an Anterior-Posterior Dimension as Used for Development of Test Items

Category	Place	Manner of Formation				
		Plosive		Fricative		Nasal
Anterior	labial	/b/	/p/	--		/m/
	labio -dental	--		/v/	/f/	--
	lingua-dental	--		/ð/	/θ/	--
Medial	lingua-alveolar	/d/	/t/	/z/	/s/	/n/
Posterior	lingua-palatal	--		/ʃ/		--
	lingua-velar	/g/	/k/	--		--

lingua-palatal and lingua-velar phonemes.

Table 7 presents the 15 two syllable sequences and the 15 three syllable sequences used in the current study. The three syllable sequences, it should be noted, are expansions of the two-syllable sequences.

EQUIPMENT

Performances of each subject were recorded on a Roberts Model 770X dual channel tape recorder at 7-1/2 ips using Scotch 175 heavy duty recording tape. The Roberts recorder provided adequate fidelity for the purposes of the study and also permitted maximal utilization of tapes. By recording monaurally, four channels were available on each tape, thus reducing the total number of tapes required for subject responses.

Because the Roberts equipment was not available for the full period of time required for the measurement and tabulation of subject responses, it was necessary to employ a Sony Stereo Tapecorder Model TC-230. To insure that changes in recorders did not affect the precision of analysis, a random sample of 15 performances recorded on the Roberts was reproduced on each machine and evaluated independently by a panel of three judges and the investigator.

The judges were asked to agree or disagree that each particular item was an accurate reproduction of the original test item. The judges reported identical statements

Table 7

Two Syllable and Three Syllable Sequences
Employed in the Study

Two Syllable Sequences	Three Syllable Sequences
/pʌtʌ/	/pʌtʌkʌ/
/bʌdʌ/	/bʌdʌgʌ/
/bʌzʌ/	/bʌzʌgʌ/
/bʌnʌ/	/bʌnʌgʌ/
/ðʌdʌ/	/ðʌdʌgʌ/
/vʌdʌ/	/vʌdʌgʌ/
/ðʌzʌ/	/ðʌzʌgʌ/
/vʌzʌ/	/vʌzʌgʌ/
/ðʌnʌ/	/ðʌnʌgʌ/
/vʌnʌ/	/vʌnʌgʌ/
/mʌdʌ/	/mʌdʌgʌ/
/mʌzʌ/	/mʌzʌgʌ/
/mʌnʌ/	/mʌnʌgʌ/
/θʌsʌ/	/θʌsʌʃʌ/
/fʌsʌ/	/fʌsʌʃʌ/

regarding the test items when reproduced on both recorders. This result indicated that, for the purposes of this study, there was no difference in the playback capabilities of the two recorders.

Tabulation of subject responses required two additional pieces of equipment: a frequency counter and a signal generator to activate the counter. A Monsanto Counter/Timer Model 101A was used to count the signals generated from a three transistor 100 cycle oscillator (multivibrator). This count was converted to time, providing a measure of each subject's duration of performance.

Counter/Timer

The Monsanto 101A Counter/Timer is an instrument which can determine average frequency, frequency ratios and single periods as well as count the total number of events. The instrument has five decade counting units which count signal pulses over a specific time interval, (gate time), or for unspecified time periods when the manual operating mode is selected. When the instrument operates in the manual mode, it functions as a total events counter. The total count obtained is displayed by five numeric readout tubes.

Calibration of the Counter/Timer. The Monsanto 101A Counter/Timer was calibrated in the following ways: (1) calibration was checked by a manufacturer's representative immediately prior to the inception of the study, approximately midway through and again at the conclusion, (2) the accuracy of the instrument was checked periodically through the use of a built-in test circuit and, (3) accuracy of results was checked periodically by comparing the Monsanto with other frequency counters.

Multivibrator

The second item of equipment is a 100 cycle multivibrator, oscillator, which was constructed for the present study. The multivibrator provides a signal which activates the counting units of the Counter/Timer.

The multivibrator is a three transistor oscillator whose waveform is a square wave with a frequency of 100 Hz. The power supply for the multivibrator is supplied by two 1.35 volt mercury cells, number 502. A potentiometer (an adjustable resistor) in the circuit makes it possible to alter the output of the multivibrator to compensate for changes in battery output.

The mercury cells have the desirable property of a constant discharge curve. This feature provides a relatively consistent power output. When the useable energy has been expended, the circuit operation ceases.

However, as the cell energy is expended, the cell changes values which in turn affects the frequency output. By adjusting the potentiometer, the frequency output can be maintained at 100 Hz until the battery must be replaced.

The multivibrator was connected to the Counter/Timer via a BNC cable. The counting units of the Monsanto

Counter/Timer were activated as long as a push-button type switch on the multivibrator was depressed. Since the multivibrator generated a signal of 100 cycles per second, the count displayed by the counter was converted to time by dividing the count by 100. This time measure provided the data for duration of performance and subsequent rate computations.

The combination of the two pieces of equipment facilitated the data analysis process in several ways. By using the manual mode operation of the Counter/Timer, the multivibrator signal could be counted as long as necessary. Consequently, a wide range of durations of performance could be measured. The equipment also permitted time measurements in hundredths of a second. Therefore, small differences among items and/or subjects could be detected.

PROCEDURES FOR DATA COLLECTION

After the subjects were selected on the basis of the criteria discussed earlier, each subject was scheduled individually for a recording of his ability to perform the 45 series of repetitions (tasks) chosen for this present study. (See Tables 5 and 7).

All data were collected in an unused classroom which was a modified barracks building. The building was isolated from most of the school's activity. Consequently, environmental noise levels were minimal.

The first few minutes of the test-recording session were used to familiarize the subject with the general nature of the recording procedures. Subjects were seated so that their lips were approximately 12 inches from the microphone.

The subjects were positioned in such a way that they could see the VU meter on the recorder. They were instructed to try to keep the meter indicator reading at zero. They were encouraged to monitor their intensity levels visually while talking. When the VU meter needle deviated from peaking at zero, the investigator used hand signals to prompt the subjects to correct the intensity level. Each subject practiced controlling the VU meter's activity until he could make the needle peak at zero for a minimum of five seconds.

After the subject became familiar with the equipment, the investigator read the following statement:

> You will be recorded as you repeat some nonsense syllables. There are 45 items. Fifteen of the items are one syllable. Fifteen of the items are two syllables and fifteen of the items have three syllables each. The items will be recorded in a scrambled order. Some of the items are very easy to repeat while others are somewhat difficult. You may practice each of the 45 items as long as you wish. Each item is written on a card to which you may refer while we are recording.
>
> Remember to take a deep breath before you begin. Repeat the item as fast as you can and as long as you can without changing the pattern and without taking another breath. It is important to go as fast as you can and as long as you can on one breath and still say it correctly.

The 45 test items were written in large print with a broad tipped felt pen on individual 5 x 8 inch cards.

The cards were placed in front of the subject to remind him of the test item.

Since the subjects were unfamiliar with the International Phonetic Alphabet, the stimulus cards used orthographic spellings instead of phonemic symbols. Consequently, /ʌ/ was represented as "uh" and /fʌ/, /θʌ/ and /ðʌ/ were written as "sh," "th," and "<u>th</u>," respectively.

The investigator presented the card to the subject and demonstrated the item. After the demonstration, the subject practiced as long as he wished. The practice period enabled the investigator to correct any mispronunciations or irregularities in the procedure.

Each item was recorded two times with a thirty-second interval between the two recordings. After the second recording of an item, the next item was demonstrated. A similar procedure of demonstration, practice and recording was used for all 45 items.

Instructions were repeated periodically throughout the recording session. The subjects also were encouraged with head nods and verbal responses, e.g., "Keep it up," "You're doing fine." These procedures were used to minimize inattention and poor self-motivation.

To minimize the effects of order and fatigue, the 45 items were presented in random order. A different order was selected for each subject each recording session.

The subjects were brought back for a second test-recording session after an interval of at least a week. The same procedures of demonstration, practice and recording of all test items were followed. In the second session, the overall procedure followed in the first session was replicated and the subjects again produced each series of the test items twice. Therefore, each of 30 subjects performed each complete test four times, producing a total N of 120 recordings.

PROCEDURES FOR DATA ENUMERATION

Count

The count for each item consists of the number of CV syllables produced correctly. This number was determined by playing and replaying the tape recordings until the investigator derived the same count three times in succession. Where it was necessary, the recording was played at slower speeds to verify the count. The derived number was used in the second phase of the data enumeration.

The count included only the total number of syllables produced correctly. In instances where the subject was able to produce the stream of repeated sounds without error, the reported count indicates the total number of syllables produced. In situations where the subject made an error somewhere in the stream of syllable repetitions, the total count reported indicates the total number of syllables produced correctly before the occurrence of the error. All portions of a two or three syllable item had to be produced correctly before they were counted.

The validity of the syllable count was checked in three ways: (1) the investigator made repeated counts of each item until the same count was found three times in succession; (2) an additional count of the syllables produced by a subject for each task was made at the time the researcher measured the time required for the task; (3) 15 items were counted independently by a panel of three judges and the investigator. There was total agreement among all evaluators on all items except for a difference in count on one item by one judge. This procedure was included within the study as a check on the reliability of the obtained measures and also served as an additional check on the validity of the measures reported by the researcher.

Duration

For purposes of the present study, duration of performance is defined as the period of time in seconds from the onset of the first syllable to the termination of the last correctly produced syllable of a series. The multivibrator's pushbutton switch was depressed with the beginning of the first syllable of a series and was released when the last correctly produced syllable in the series was completed. The display on the counting units of the Counter/Timer was noted. Multiple timings of each syllable series were made until a minimum of three measurements were acquired. These measurements were averaged and the mean was converted to time in seconds by dividing by 100. The result was used in the statistical computations.

To be accepted for computation, a measurement had to meet the following criteria:

1. In the opinion of the investigator, the onset of the syllable coincided with the depression of the multivibrator switch and the last correctly produced syllable terminated with the release of the switch.

2. Only measurements that met the above criterion and differed no more than .06 seconds were averaged. This range of .06 seconds was selected arbitrarily as the maximum permissible deviation in time. When repeated measurements exceeded the chosen accuracy standard, the measurement process was continued until three acceptable measurements were acquired.

Validity of measurements was of major concern and the accuracy of the measurement procedures was checked in three ways. One method compared the results of a graphic level recorder write-out (Bruel and Kjaer Level Recorder, Type 2305), for 15 items selected at random with the results derived by the investigator for the same items. No differences in results were found.

The second and third methods employed other judges to assess inter and intra judge reliability and validity of measurements. In one procedure, a panel of three judges independently made duration measurements on 15 randomly selected items. These results were compared with the results derived by the investigator and Pearson product-moment correlations coefficients were computed. In each instance, the results of the investigator and the judge were highly correlated, with $r = .99$.

In a third procedure to check validity of duration measures, each of the judges remeasured a sample of the measurements made previously. In addition, each judge performed a series of measurements which were checked by either the investigator or another judge. This procedure provided aperiodic checks of the investigator's measurements.

Prior to measuring each test item, the output of the multivibrator was checked. To accomplish this check, the Counter/Timer was set in frequency mode with gate time of 1 second. At least 5 measurements were made, with three of the five averaging 100 cycles per second, and the remaining trials deviating no more than $\pm$ one count.

STATISTICAL ANALYSIS

Data were analyzed using a split plot arrangement of treatments in a completely randomized design where sex was the main factor, with 15 subjects per sex. The subfactors were a 45 x 2 factorial arrangement of treatments (45 tests x 2 times) with two observations per subject-item-time combination. Data were analyzed for criterion measures of rate and duration. Individual comparisons among test items were conducted. Alpha was set at 0.05.

Statistical computations were performed on a IBM 360 Model 65 computer.

CHAPTER IV

RESULTS AND DISCUSSION

MAIN EFFECTS - RESULTS

Means for the 45 test items were computed for the criterion measures of rate and duration. An analysis of variance was performed for each criterion measure and the results of these analyses are summarized in Tables 8 and 9. These procedures provided the basis for more detailed statistical analyses.

There were no significant differences between sexes in the overall analyses for rate and duration. Experimental and sampling errors were pooled since the experimental error was not significant when tested with the sampling error.

[With 44 and 5200 df, $F_{.05} = 1.38$; $F_{.01} = 1.56$
With 1 and 28 df, $F_{.05} = 4.20$; $F_{.01} = 7.64$]

Table 8 presents the analysis of variance for rate. Although there were no significant differences found between sexes in the overall analysis, there were significant differences ($p<0.01$) among times and tests. The interactions of sex with time and time with test were also highly significant ($p<0.01$). Interaction between sex and test was significant at the 0.05 level. However, interaction between sex and time and test was not significant. These results indicate that the observed differences in rate tend to be peculiar to selected conditions.

Table 8

Analysis of Variance for Criterion Measure of Rate, Split-Plot, Completely Randomized Design (N = 120)

Source of variation	df	SS	MS	F
Sex	1	41.93	41.93	<1
Subject/Sex	28	1318.26	47.08	
Time	1	81.13	81.13	139.68**
Test	44	2353.80	53.50	92.24**
Sex x Time	1	2.42	2.42	4.16**
Sex x Test	44	37.21	0.85	1.46*
Time x Test	44	57.71	1.31	2.26**
Sex x Time x Test	44	27.63	0.63	1.08
Error	5192	3015.53	0.58	
Corrected Total	5399	6335.62		

The observations within subject x time x test source of variation has been pooled with the experimental error as the experimental error was not significant.

* $p<0.05$

** $p<0.01$

Table 9 presents the analysis of variance for duration. Consistent with the analysis for rate, differences in sex were not significant in the overall analysis. Experimental error and sampling error were pooled as was the case for rate. Analysis of subfactors indicates that significant differences at the 0.01 level exist for time, test and sex by time interaction. Interaction between time and test was significant at the 0.05 level. Interactions between sex and test and sex x time x test were not significant. Again, it can be concluded that differences in duration vary according to selected conditions.

Table 9

Analysis of Variance for Criterion Measure of Duration, Split-Plot, Completely Randomized Design (N = 120)

Source of Variation	df	SS	MS	F
Sex	1	373.04	373.04	<1
Subject/Sex	28	32781.78	1170.78	
Time	1	1425.74	1425.74	227.24**
Test	44	7538.17	171.32	27.32**
Sex x Time	1	72.39	72.39	11.55**
Sex x Test	44	360.72	8.20	1.31
Time x Test	44	413.82	9.41	1.50*
Sex x Time x Test	44	256.82	5.84	
Error	5192	32575.60	6.27	
Corrected Total	5399	75798.07		

The observations within subject x time x test source of variation has been pooled with the experimental error as the experimental error was not significant.

* $p<0.05$

** $p<0.01$

The effects of some of these conditions are presented in Tables 10, 11, and 12. Table 10 presents the means for rate and duration for sexes averaged over all times and tests. Although the means were not significantly different in the overall analysis, females performed slightly better on both criterion measures.

Table 11 presents the presents the means for rate and duration for the two testing periods. Both criterion measures show improvement in the second testing situation over the initial period. The data presented in Table 11 are graphically displayed in Figures 1 and 2.

Table 10

Means for Rate* and Duration** for 15 Males and 15 Females with Two Observations Each Time for Times 1 and 2 for 45 Test Items

Sex	N	Means Rate	Means Duration
Male	2700	5.30	8.01
Female	2700	5.47	8.54
Overall Means	5400	5.39	8.28

* Rate = number of syllables per second
** Duration = time in seconds of total utterances

Means for rate and duration for each sex and each test period are displayed in Table 12. The two performances within each testing period have been combined for each of the 45 test items, producing an N of 1350. While both sexes

Table 11

Means for Rate* and Duration** for Times 1 and 2 with Male and Female Subjects (N = 30) for 45 Test Items (2 Performances Per Time)

Time	N	Means	
		Rate	Duration
1	2700	5.26	7.76
2	2700	5.51	8.79
Overall Means	5400	5.39	8.28

* Rate = number of syllables per second
** Duration = time in seconds of total utterances

Table 12

Means for Rate* and Duration** for Sex and Time, with 2 Performances Per Time, for 15 Males and 15 Females for 45 Test Items (N = 1350)

Sex	Time	N	Means	
			Rate	Duration
Male	1	1350	5.20	7.61
Male	2	1350	5.40	8.41
Female	1	1350	5.33	7.91
Female	2	1350	5.62	9.17
Overall Means		5400	5.39	8.28

* Rate = number of syllables per second
** Duration = sex in seconds for total utterances

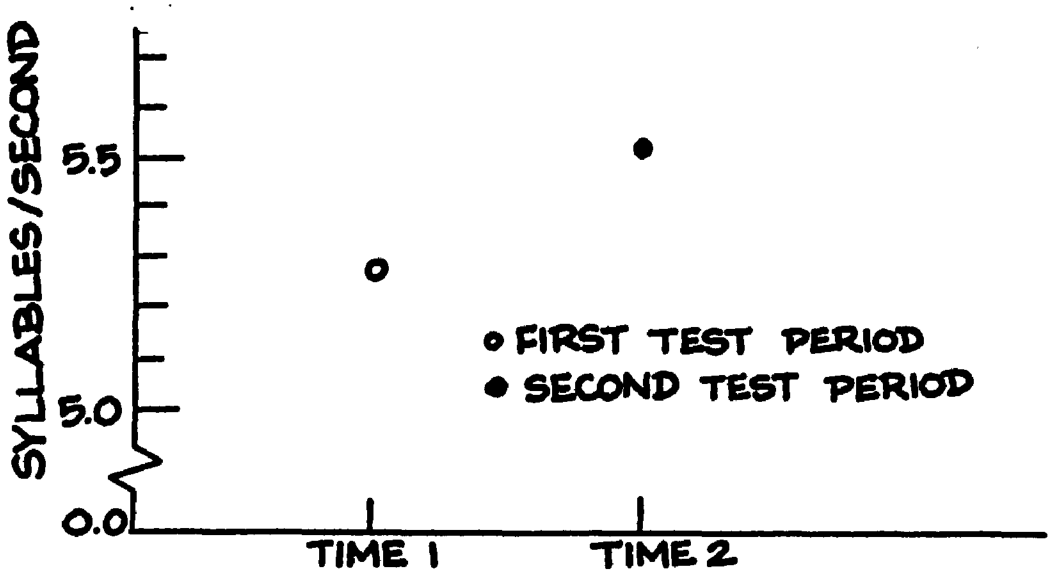

Figure 1

Mean rate for Times 1 and 2

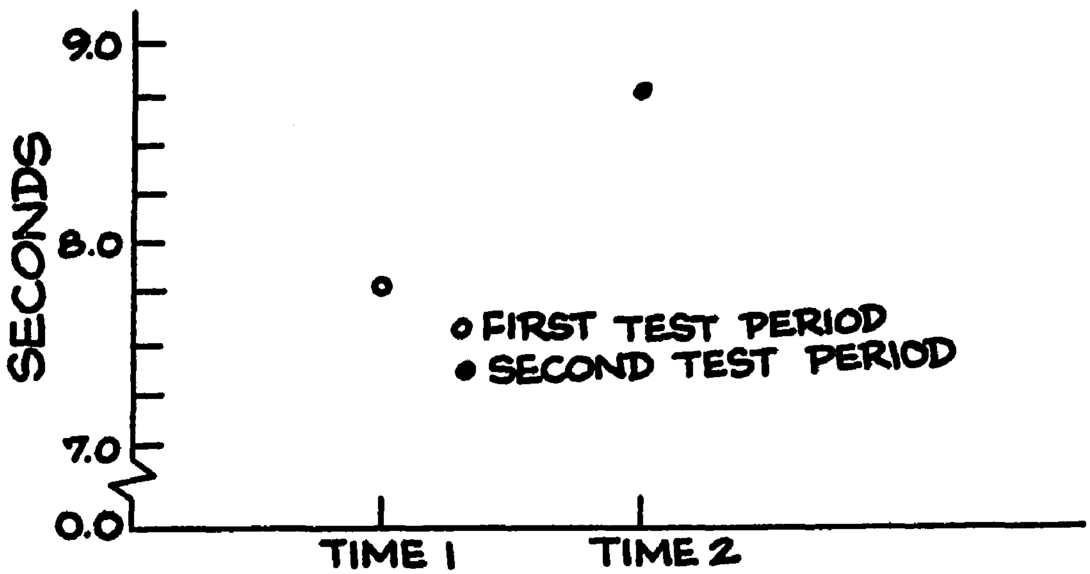

Figure 2

Mean Duration for Times 1 and 2

improved from Time 1 to Time 2 on both criteria, females made more of an improvement. The changes in performance across time are shown in Figures 3 and 4.

Scores of male and female subjects were not considered separately in the derivation of means for rate and duration for the various test items. When 120 events are used as the N, they include the performance of 30 subjects (15 male, 15 female) performing each test item in two different testing periods with two performances in each testing period. When N is 60, the scores of male and female subjects were considered separately for two performances in each of two testing periods.

Table 13 presents the means for all performances for the 15 single syllable test items. For purposes of comparisons among the syllables, the rank order of the obtained data is given for measures of rate and measures of duration. Measures for the CV syllable /pʌ/ had the highest mean number of syllables per second (5.68), /zʌ/ the fewest number of repetitions per second (4.51). The syllable /pʌ/ was repeated for the longest time (11.10 seconds), performances of /ʃʌ/ were sustained for the shortest period of time (7.33 seconds). The rank orders are only gross indications of the relative size of the means.

With the exception of velar syllables, plosive and nasal syllables were produced at faster rates than the fricative syllables. The fastest syllable rates were for the labial and lingua-alveolar plosives. Next in order

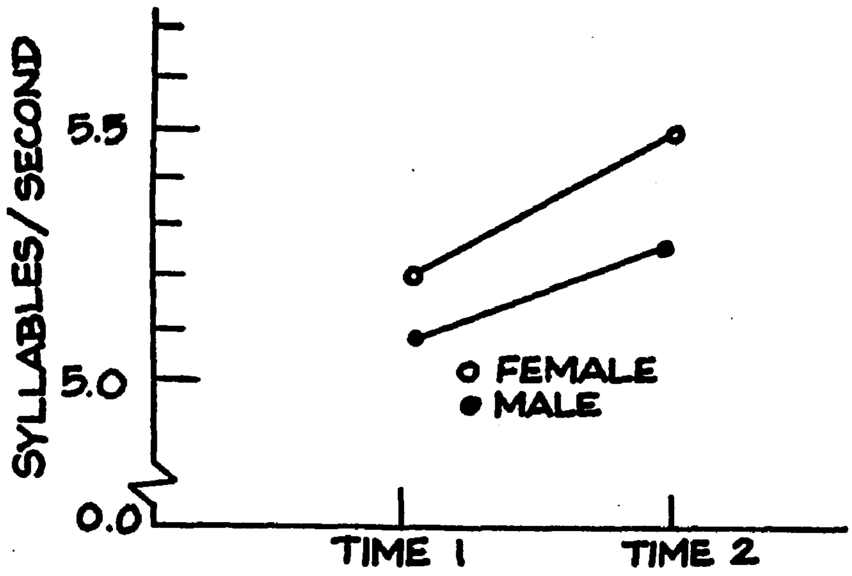

Figure 3

Mean Rate for Males and Females
for Times 1 and 2

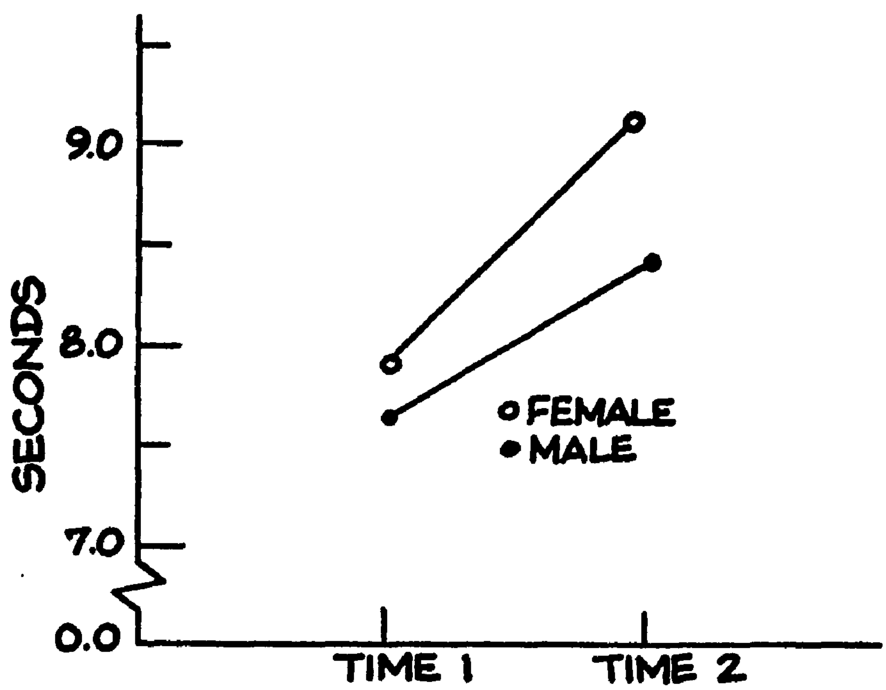

Figure 4

Mean Duration for Males and Females
for Times 1 and Times 2

Table 13

Means and Rank Order for Rate and Duration for 15 Single Syllable Items for 15 Males and 15 Females Combined with 2 Performances Each for Two Time Periods (N = 120)

Grouped by Manner of Formation

Item	Rate Mean	Rate Rank Order	Duration Mean	Duration Rank Order
Plosives				
/pʌ/	5.68	1	11.10	1
/bʌ/	5.53	4	10.77	3
/tʌ/	5.55	2	10.15	4
/dʌ/	5.54	3	10.84	2
/kʌ/	4.88	9	9.12	11
/gʌ/	4.86	10	9.75	6
Fricatives				
/fʌ/	5.12	8	9.18	10
/vʌ/	5.17	7	9.60	8
/θʌ/	4.81	11	9.07	13
/ðʌ/	4.81	11	9.09	12
/sʌ/	4.64	13	8.52	14
/zʌ/	4.51	15	9.59	9
/ʃʌ/	4.53	14	7.33	15
Nasals				
/mʌ/	5.19	6	9.69	7
/nʌ/	5.36	5	9.90	5

were the labial and lingua-alveolar nasal syllables. The labio-dental fricatives, velar plosives, lingua-dental, lingua-alveolar, and lingua-palatal fricatives followed.

With the exception of /kʌ/, plosive syllables had longer durations than fricative and nasal syllables. Fricative syllables were sustained for shorter periods of time than either the plosive or nasal syllables.

Consistent with the results for rate, repetitions of the labial and lingua-alveolar plosive syllables were sustained longer than other syllables. The nasal lingua-alveolar syllable, voiced velar plosive syllable and the nasal labial syllable were next in an ordering of duration times. The longest sustained fricative syllables were /vʌ/, /zʌ/, and /fʌ/. The voiceless velar plosive syllable was sustained longer than the lingua-dental fricative, voiceless lingua-alveolar and lingua-palatal fricative syllables.

Table 14 shows the means for all performances for rate and duration for the 15 two syllable test items. Rank ordering of the data is given for convenience in comparing means.

Rate of repetitions was fastest for /pʌtʌ/ (6.43 syllables per second) and slowest for /θʌsʌ/ (3.82 syllables per second). Syllables characterized by labial and lingua-alveolar plosive and nasal consonants tended to be produced at faster rates than syllables incorporating one or more fricative phonemes.

Table 14

Means and Rank Order for Rate and Duration for 15 Two Syllable Test Items for 15 Males and 15 Females Combined with 2 Performances Each for 2 Time Periods (N = 120)

Items	Rate		Duration	
	Mean	Rank Order	Mean	Rank Order
/pʌtʌ/	6.43	1	7.76	9
/bʌdʌ/	6.36	2	8.20	4
/bʌzʌ/	5.34	7	8.76	1
/bʌnʌ/	5.83	4	8.04	5
/ðʌdʌ/	4.60	13	7.10	12
/vʌdʌ/	5.69	6	7.93	7
/ðʌzʌ/	4.12	14	6.55	15
/vʌzʌ/	5.01	10	7.94	6
/ðʌnʌ/	4.84	12	7.44	11
/vʌnʌ/	5.82	5	8.48	2
/θʌsʌ/	3.82	15	6.92	13
/fʌsʌ/	4.99	11	7.49	10
/mʌdʌ/	5.51	9	6.78	14
/mʌzʌ/	5.34	7	8.41	3
/mʌnʌ/	6.12	3	7.80	8

Duration of repetitions was longest for /bʌzʌ/ (8.76 seconds) and shortest for /ðʌzʌ/ (6.55 seconds). Examination of Table 14 does not reveal any clear pattern for differences in duration. Plosive, nasal and fricative syllables are well represented as initial and final syllables among the longer sustained syllable sequences. Voiced sequences tend to be produced for longer duration than those sequences containing unvoiced consonants.

Table 15 displays the means for rate and for duration for the 15 three-syllable test items. Rank order for rate indicates that /bʌdʌgʌ/ was the fastest produced syllable while /θʌsʌʃʌ/ was the slowest sequence. Sequences containing a plosive or nasal lingua-alveolar syllable were produced faster. The slower sequences frequently had one or more fricative syllables. Syllables composed of voiceless fricatives /θʌsʌʃʌ/ and /fʌsʌʃʌ/ , not surprisingly, were the slowest sequences.

Duration for the 15 syllable items was longest for /vʌzʌgʌ/ and shortest for /mʌdʌgʌ/ . The limited duration for /mʌdʌgʌ/ is related in part to the inability of subjects to repeat the sequence many times before changing or omitting the required phonemes in the pattern. With the exception of /vʌzʌgʌ/, sequences with longer duration contained nasal or plosive medial syllables. Initial syllables containing all three types of consonants were represented among the longer time sequences.

Table 16 summarizes the means for rate and duration

Table 15

Means and Rank Order for Rate and Duration for 15 Three Syllable Test Items for 15 Males and 15 Females (Combined) for 2 Performances Each for 2 Time Periods (N = 120)

Items	Rate		Duration	
	Mean	Rank Order	Mean	Rank Order
/pʌtʌkʌ/	6.24	2	8.01	3
/bʌdʌgʌ/	6.28	1	7.62	11
/bʌzʌgʌ/	5.92	8	7.91	6
/bʌnʌgʌ/	5.97	7	8.04	5
/ðʌdʌgʌ/	5.80	10	7.64	10
/vʌdʌgʌ/	6.23	3	7.75	7
/ðʌzʌgʌ/	5.40	13	6.92	13
/vʌzʌgʌ/	5.75	12	8.18	1
/ðʌnʌgʌ/	5.80	10	7.68	9
/vʌnʌgʌ/	6.21	4	8.12	2
/θʌsʌʃʌ/	4.10	15	6.33	14
/fʌsʌʃʌ/	4.58	14	6.94	12
/mʌdʌgʌ/	6.19	5	6.29	15
/mʌzʌgʌ/	5.84	9	7.69	8
/mʌnʌgʌ/	6.09	6	8.01	3

Table 16

Means for Rate and Duration of 15 Single Syllable Items for 15 Males and 15 Females with 2 Performances for Each of 2 Testing Times (N = 60 for Each Sex)

Item	Means: Rate Male	Rate Female	Duration Male	Duration Female
/pʌ/	5.49	5.87	11.58	10.63
/bʌ/	5.52	5.54	10.07	11.47
/tʌ/	5.62	5.48	10.32	9.98
/dʌ/	5.48	5.59	10.31	11.38
/kʌ/	4.85	4.90	9.30	8.93
/gʌ/	4.79	4.92	9.15	10.35
/fʌ/	5.04	5.20	8.71	9.65
/vʌ/	5.21	5.14	8.87	10.33
/θʌ/	4.73	4.89	9.05	9.09
/ðʌ/	4.83	4.78	8.33	9.84
/sʌ/	4.67	4.62	8.35	8.69
/zʌ/	4.41	4.62	9.13	10.06
/ʃʌ/	4.44	4.62	7.49	7.18
/mʌ/	5.14	5.24	9.35	10.03
/nʌ/	5.48	5.23	9.47	10.34

of the 15 single syllable items for each sex. Examination of the means shows that females achieved higher means for both rate and duration on approximately two-thirds of the items. The females produced all but one of the plosive syllables, /tʌ/, faster than the males. They also exceeded the rate of the males for four of the fricative syllables (/fʌ/, /θʌ/, /zʌ/, /ʃʌ/) and one of the nasal syllables (/mʌ/).

With the exception of /ʃʌ/, the females had longer duration means for the fricative syllables and for all of the nasal syllables. Longer duration means were equally divided between the sexes for the plosive syllable (Males: /pʌ/, /tʌ/, /kʌ/; Females: /bʌ/, /dʌ/, /gʌ/).

The means for rate and duration for the 15 two syllable items by each sex are summarized in Table 17. Means for both rate and duration are higher for the female for all items.

Table 18 presents the means for rate and duration for the 15 three syllable items for each sex. Females achieved faster rates than did males for all items except /bʌdʌgʌ/, /vʌzʌgʌ/ , and /mʌzʌgʌ/ . The females also achieved longer duration means for all items except for /bʌdʌgʌ/ and /vʌdʌgʌ/ .

Table 19 displays the means for rate and duration for the 15 single syllable items for Time 1 and Time 2. Slightly over half of the test items were produced at a higher mean rate during the second test period than in the

Table 17

Means for Rate and Duration of 15 Two Syllable Stimulus Items for 15 Males and 15 Females with 2 Performances for Each of 2 Testing Times (N = 60 for Each Sex)

Item	Means: Rate Male	Rate Female	Duration Male	Duration Female
/pʌtʌ/	6.27	6.58	7.40	8.12
/bʌdʌ/	6.25	6.47	7.78	8.63
/bʌzʌ/	5.31	5.37	8.22	9.30
/bʌnʌ/	5.74	5.93	7.93	8.14
/ðʌdʌ/	4.41	4.78	6.79	7.41
/vʌdʌ/	5.45	5.92	7.55	8.32
/ðʌzʌ/	3.96	4.27	6.40	6.70
/vʌzʌ/	4.91	5.12	7.41	8.47
/ðʌnʌ/	4.64	5.04	6.95	7.93
/vʌnʌ/	5.65	5.99	8.23	8.72
/θʌsʌ/	3.73	3.91	6.74	7.09
/fʌsʌ/	4.82	5.15	7.23	7.74
/mʌdʌ/	5.49	5.54	6.23	7.33
/mʌzʌ/	5.23	5.46	8.12	8.71
/mʌnʌ/	6.00	6.24	7.66	7.93

Table 18

Means for Rate and Duration of 15 Three Syllable Stimulus Items for 15 Males and 15 Females with 2 Performances for Each of 2 Testing Times (N = 60 for Each Sex)

Item	Means			
	Rate		Duration	
	Male	Female	Male	Female
/pʌtʌkʌ/	5.99	6.49	7.88	8.14
/bʌdʌgʌ/	6.28	6.28	7.70	7.53
/bʌzʌgʌ/	5.88	5.97	7.89	7.93
/bʌnʌgʌ/	5.86	6.08	8.03	8.05
/ðʌnʌgʌ/	5.57	6.03	7.25	8.02
/vʌdʌgʌ/	6.14	6.32	7.80	7.71
/ðʌzʌgʌ/	5.20	5.60	6.84	7.01
/vʌzʌgʌ/	5.75	5.74	7.81	8.55
/ðʌnʌgʌ/	5.64	5.95	7.37	7.99
/vʌnʌgʌ/	6.15	6.26	8.02	8.23
/θʌsʌʃʌ/	3.98	4.21	5.99	6.66
/fʌsʌʃʌ/	4.44	4.72	6.73	7.15
/mʌdʌgʌ/	6.06	6.32	5.88	6.70
/mʌzʌgʌ/	5.86	5.83	7.52	7.84
/mʌnʌgʌ/	6.03	6.15	7.79	8.24

Table 19

Means for Rate and Duration for 15 Single Syllable Stimulus Items for 15 Males and 15 Females (Combined) with 2 Performances Each for Time 1 and Time 2 (N = 60)

Item	Means			
	Rate		Duration	
	Time 1	Time 2	Time 1	Time 2
/pʌ/	5.87	5.49	10.87	11.33
/bʌ/	5.54	5.52	10.48	11.07
/tʌ/	5.53	5.57	9.61	10.69
/dʌ/	5.55	5.52	10.34	11.35
/kʌ/	4.91	4.84	8.49	9.74
/gʌ/	4.89	4.83	9.54	9.96
/fʌ/	5.06	5.17	9.20	9.17
/vʌ/	5.19	5.15	9.25	9.95
/θʌ/	4.73	4.89	8.90	9.24
/ðʌ/	4.78	4.83	8.55	9.62
/sʌ/	4.55	4.73	8.37	8.67
/zʌ/	4.45	4.58	9.52	9.67
/ʃʌ/	4.42	4.64	6.89	7.78
/mʌ/	5.10	5.28	9.52	9.86
/nʌ/	5.33	5.38	9.71	10.10

first test time. With the exception of /fʌ/, all items were performed for a longer time during the second test period than in the initial test.

Table 20 contains the means for rate and duration for the 15 two syllable items for Time 1 and Time 2. Consistent with the data presented in Table 15, means for the two syllable items increased from Time 1 to Time 2. All duration means increased between the two test periods, and with the exception of /mʌdʌ/, all rate means also increased.

Table 21 presents the data for the 15 three syllable items for Time 1 and Time 2. Means for both rate and duration increased for all items during the second testing period.

HYPOTHESES RELATED TO SEX AND RELIABILITY

Sex

Hypothesis 1: The rate of performance in the repetition of syllabic utterances does not differ significantly by sex is not rejected on the basis of the data presented in Table 8.

Hypothesis 2: The duration of performance in the repetition of syllabic utterances does not differ significantly by sex is not rejected on the basis of the data presented in Table 9.

The overall analyses of variance in Tables 8 and 9 revealed no significant differences between the performance

Table 20

Means for Rate and Duration for 15 Two Syllable Stimulus Items for 15 Males and 15 Females (Combined)with 2 Performances Each for Time 1 and for Time 2 (N = 60 for Each Time)

Item	Means			
	Rate		Duration	
	Time 1	Time 2	Time 1	Time 2
/pʌtʌ/	6.32	6.53	6.99	8.53
/bʌdʌ/	6.24	6.48	7.31	9.09
/bʌzʌ/	5.13	5.55	7.94	9.58
/bʌnʌ/	5.80	5.86	7.71	8.36
/ðʌdʌ/	4.51	4.68	6.41	7.80
/vʌdʌ/	5.48	5.89	7.27	8.59
/ðʌzʌ/	3.96	4.27	5.71	7.39
/vʌzʌ/	4.87	5.15	7.60	8.28
/ðʌnʌ/	4.65	5.03	6.71	8.16
/vʌnʌ/	5.68	5.96	8.44	8.51
/θʌsʌ/	3.55	4.08	6.42	7.42
/fʌsʌ/	4.74	5.23	6.77	8.21
/mʌdʌ/	5.54	5.48	6.50	7.05
/mʌzʌ/	5.22	5.47	7.89	8.94
/mʌnʌ/	5.85	6.39	7.30	8.30

Table 21

Means for Rate and Duration for 15 Three Syllable Stimulus Items for 15 Males and 15 Females (Combined) with 2 Performances Each for Time 1 and Time 2 (N = 60 Each Time)

Items	Means			
	Rate		Duration	
	Time 1	Time 2	Time 1	Time 2
/pʌtʌkʌ/	6.06	6.42	6.90	9.12
/bʌdʌgʌ/	6.08	6.49	7.21	8.02
/bʌzʌgʌ/	5.64	6.20	7.07	8.74
/bʌnʌgʌ/	5.87	6.07	7.52	8.55
/ðʌdʌgʌ/	5.63	5.97	7.04	8.23
/vʌdʌgʌ/	5.98	6.49	6.58	8.93
/ðʌzʌgʌ/	5.22	5.58	6.19	7.66
/vʌzʌgʌ/	5.60	5.89	7.36	8.99
/ðʌnʌgʌ/	5.54	6.06	7.29	8.06
/vʌnʌgʌ/	6.01	6.40	7.33	8.92
/θʌsʌʃʌ/	3.83	4.37	5.83	6.82
/fʌsʌʃʌ/	4.34	4.82	6.64	7.23
/mʌdʌgʌ/	6.07	6.31	5.71	6.87
/mʌzʌgʌ/	5.66	6.03	6.82	8.54
/mʌnʌgʌ/	5.89	6.29	7.60	8.43

of males and females. The findings in this study pertaining to rate differences between sexes concur with the results reported by Blomquist (1950) and by Fairbanks and his associates (1950a, 1950b).

Means reported in Table 10 show that performance for all measures by females were slightly faster than those by males and were sustained slightly longer than those by males. These results disagree with the observations of West (1929), Lundeen (1950) and Irwin and Becklund (1953).

When performances by sexes were analyzed for interaction with times of testing in Tables 8 and 9, the interaction for both rate and duration was significant ($p<0.01$). Data in Table 12 shows that, while both males and females improved from Time 1 to Time 2, females made greater improvement for both criterion measures.

Data in Tables 16, 17 and 18 indicate that performances by sex vary with test items. When sex x test item interaction was tested in Tables 8 and 9, the interaction was significant only for rate ($p<0.05$).

In summarizing the effects of sex on the criterion measures of rate and duration, data from the present study suggest there are differences in performance between sexes some of the time which may be obscured by comparing total performance of males. While the data in this study suggest that sex differences are revealed in measures obtained over time and with different test items, no explanation can be offered to account for the observed differences. Males and females apparently perform differently with regard to different times and with different test items.

It is possible that, with nearly 5200 degrees of freedom, the sensitivity of the statistical procedures was such that very small differences were detected. Differences which are significant in a statistical test with 5200 degrees of freedom may not be significant when viewed pragmatically.

It is possible that the significant interaction found in sex x time and sex x test analyses may be related to factors such as motivation and anxiety that may be a function of sex. Further investigation of these interactions may be merited.

Reliability

Hypothesis 3: Rate measures obtained for repetitions of syllabic utterances within test periods do not differ significantly is not rejected on the basis of the data in Table 8.

Hypothesis 4: Duration measures obtained for repetitions of syllabic utterances within test periods do not differ significantly is not rejected on the basis of the data in Table 9.

Hypothesis 5: Rate measures obtained for repetitions of syllabic utterances do not differ significantly between test periods is rejected on the basis of data in Table 8.

Hypothesis 6: Duration measures obtained for repetitions of syllabic utterances do not differ significantly between test periods is rejected on the basis of data presented in Table 9.

Hypotheses 3 and 4 relate to short-term reliability of the criterion measures. When within test period means were tested, the means were not significantly different. The variances were pooled in the experimental error in Tables 8 and 9. The small mean square error in Table 8 (0.58) is indicative of highly reliable measures for rate. The somewhat larger mean square error (6.27) in Table 9 suggests that duration measures are more variable, although the variance is not significant within test periods. The results in this present study are compatible with those of Blomquist (1950).

Hypotheses 5 and 6 are concerned with long-term reliability of the criterion measures of rate and duration. The analyses of variance in Tables 8 and 9 indicate that the differences in the measures obtained in the first and in the second testing periods were highly significant ($p < 0.01$). The data in this present study show that means for all subjects combined were higher for rate and duration measures for Time 2 than for Time 1.

Examination of the data revealed a significant difference ($p<0.01$) between test periods for males and females with respect to interaction between sex and time for rate and duration. Apparently the male and female subjects perform differently at different times. Means for test items also appear to vary with different test periods (rate, $p<0.01$; duration, $p<0.05$).

Since this study was concerned with reliability of measures over time and the data indicated that the obtained means were significantly different for the two test periods, Pearson product-moment correlations were performed. The means were highly correlated for both rate and duration (rate, $r = .94$; duration, $r = .90$).

The high correlations between the means of the two test periods indicate that, although the means are different, they are highly related to one another. While the combined subjects increased the number of syllables produced per second and sustained their performance longer during the second test period, they apparently kept the same relationships among subjects that were present in Time 1.

It is conceivable that means obtained at a third or fourth test session also could differ. The results in this study suggest that means *per se* for rate and duration may not be meaningful without specification of the number of test periods. Further research into variables affecting reliability is indicated.

Test Items

The analyses of variance previously shown in Tables 8 and 9 indicate that rate and duration means for test items were significantly different at the 0.01 level. In addition, performances of the test items were related to test periods (rate, $p<0.01$; duration, $p<0.05$) and the number of syllables produced per second was related to performances by sex ($p<0.05$).

In order to explore factors contributing to the differences revealed in the data, individual comparisons were made between selected test items. Although all comparisons were not independent, the error that resulted was not considered sufficient to invalidate the interpretation of the statistical tests. The results of the individual comparisons will be presented in conjunction with the hypotheses testing factors of place of articulation, manner of formation, and voicing as they relate to rate and to duration. Tables 22, 23 and 24 present the individual comparisons among test items for rate. The comparisons reflect the distribution of places of articulation by the categories of anterior, medial and posterior placement used for the present study and by manner of formation.

HYPOTHESES RELATED TO RATE AND PLACE OF ARTICULATION

Hypothesis 7: Rate of repetitions of syllabic utterances is not related to place of articulation when manner of formation is held constant

Table 22

Individual Comparisons of Rate for Single Syllable Items (N = 120)

Comparisons[1]	SS	F
1. /pʌ, tʌ, kʌ/ vs. /bʌ, dʌ, gʌ/	6793.25	1.17
2. /fʌ, θʌ, sʌ/ vs. /vʌ, ðʌ, zʌ/	1267.30	0.22
3. /pʌ, tʌ, kʌ, bʌ, dʌ, gʌ/ vs. /fʌ, θʌ, sʌ, vʌ, ðʌ, zʌ/	877996.25	151.17**
4. /bʌ/ vs. /mʌ/	70138.13	12.08**
5. /pʌ, tʌ/ vs. /kʌ/	436364.50	75.13**
6. /pʌ/ vs. /tʌ/	10249.21	1.76
7. /bʌ, dʌ/ vs. /gʌ/	365688.63	62.96**
8. /bʌ/ vs. /dʌ/	24.57	0.0
9. /fʌ, θʌ/ vs. /sʌ/	82330.44	14.18**
10. /fʌ/ vs. /θʌ/	57362.47	9.88**
11. /vʌ, ðʌ/ vs. /zʌ/	180232.81	31.03**
12. /vʌ/ vs. /ðʌ/	81033.75	13.95**
13. /mʌ/ vs. /nʌ/	16894.16	2.91
14. /vʌ, ðʌ, zʌ/ vs. /ʃʌ/	79941.75	13.76**
15. /pʌ, tʌ, kʌ, bʌ, dʌ, gʌ/ vs. /mʌ, nʌ/	7972.29	1.37
16. /fʌ, vʌ, θʌ, ðʌ, sʌ, zʌ/ vs. /mʌ, nʌ/	328651.88	56.59**
Error source of variation = 5808.03 with 5192df		

[1]This does not represent a completely orthogonal set of comparisons.

** $p<0.01$

Table 23

Individual Comparisons of Rate for
Two Syllable Items
(N = 120)

Comparisons[1]	SS	F
1. /pʌtʌ/ vs. /bʌdʌ/	2790.60	0.48
2. /bʌdʌ/ vs. /ðʌzʌ, vʌzʌ/	2578772.00	444.00**
3. /bʌdʌ, vʌzʌ/ vs. /mʌnʌ/	151275.44	26.05**
4. /ðʌzʌ/ vs. /vʌzʌ/	483627.19	83.27**
5. /pʌtʌ/ vs. /θʌsʌ, fʌsʌ/	3286005.00	565.77**
6. /θʌsʌ/ vs. /fʌsʌ/	819654.00	141.12**
Error source of variation = 5808.03 with 5192 df		

[1]This does not represent a completely orthogonal set of comparisons.

** $p < 0.01$

Table 24

Individual Comparisons of Rate for
Three Syllable Test Items
(N = 120)

Comparisons[1]	SS	F
1. /pʌtʌkʌ/ vs. /bʌdʌgʌ/	1269.65	0.22
2. /pʌtʌkʌ/ vs. /θʌsʌʃʌ, fʌsʌʃʌ/	2886629.00	497.01**
3. /θʌsʌʃʌ/ vs. /fʌsʌʃʌ/	140611.13	24.21**
Error source of variation = 5808.03 with 5192 df		

[1]This does not represent a completely orthogonal set of comparisons.

** $p < 0.01$

is rejected under selected conditions.

Hypothesis 7a: Rate of repetitions of syllabic utterances does not differ significantly between labial and lingua-alveolar CV syllables is not rejected.

This hypothesis was tested in several comparisons as shown in Table 22. Comparison 6, /pʌ/ vs. /tʌ/, and Comparison 8, /kʌ/ vs. /dʌ/, tested plosive syllable relationships. Comparison 13, /mʌ/ vs. /nʌ/, compared nasal syllables. None of the comparisons were significant.

Hypothesis 7b: Rate of repetitions of syllabic utterances does not differ significantly between labial and lingua-velar CV syllables is rejected.

Comparison 5, /pʌ, tʌ/ vs. /kʌ/ and Comparison 7, /bʌ dʌ/ vs. /gʌ/, tested this hypothesis. Both comparisons (Table 22) were significant at the 0.01 level. Since Comparisons 6, (/pʌ/ vs. /tʌ/) and 8, (/bʌ/ vs. /dʌ/) were not significantly different, labial and lingua-velar CV syllables appear to be significantly different. These results are consistent with those reported by Lundeen (1950), Canter (1965), Hixon and Hardy (1964), Prins (1962), and Bitonti (1969).

Hypothesis 7c: Rate of repetitions

<u>of syllabic utterances does not differ significantly between labio-dental and lingua-dental CV syllables is rejected</u>.

This hypothesis was tested in Comparison 10, /fʌ/ <u>vs</u>. /θʌ/ and in Comparison 12, /vʌ/ <u>vs</u>. /ðʌ/ (Table 22). Both comparisons were significant at the 0.01 level, and the hypothesis was rejected.

Differences between these places of articulation were also tested in the two syllable sequences presented in Table 23. Comparison 4, /ðʌzʌ/ <u>vs</u>. /vʌzʌ/ and Comparison 6, /θʌsʌ/ <u>vs</u>. /fʌsʌ/ were significantly different (0.01). Comparison 3 in Table 24 indicates that /θʌsʌʃʌ/ <u>vs</u>. /fʌsʌʃʌ/ are significantly different (0.01). These results support the previous data that fricative vowel utterances initiated with a labio-dental differ from those initiated with a lingua-dental.

<u>Hypothesis 7d: Rate of repetitions of syllabic utterances does not differ significantly between CV syllables with labio-dental and lingua-dental consonants and CV syllables with lingua-alveolar consonants is rejected</u>.

This study was concerned with shifts of articulation from anterior places to more posterior places of articulation. Since labio-dental and lingua-dental fricatives are more anterior than the lingua-alveolar fricatives, the anterior places were combined in Comparison 9, /fʌ, θʌ/ vs. /sʌ/ and in Comparison 11, /vʌ, ðʌ/ vs. /zʌ/ (Table 22). Both comparisons were significantly different at the 0.01 level and the hypothesis was rejected. Since the comparisons include places of articulation that were found to be significantly different in Hypothesis 7c, it is not clear whether labio-dental and lingua-alveolar syllables differ and whether lingua-dental and lingua-alveolar syllables differ significantly. Further comparisons are in order. All that can be concluded from the present study is that factors influencing the rates for more anterior fricatives are different from factors for medial fricatives. These results are compatible with Lundeen's study (1950).

Hypothesis 7e: Rate of repetitions of syllabic utterances does not differ significantly between CV syllables with labio-dental and lingua-dental consonants and CV syllables with lingua-palatal consonants is rejected.

This hypothesis was explored in Comparison 14, /vʌ, ðʌ zʌ/ vs. /ʃʌ/ (Table 22). The comparison was significant at the 0.01 level and the hypothesis was rejected.

Since differences in Comparisons 11 and 12 are both significant, it is not clear what contributions the various places of articulation, i.e., labio-dental, lingua-dental, and lingua-alveolar, make to the significant difference found. Further statistical procedures are indicated.

> Hypothesis 7f: Rate of repetitions of syllabic utterances does not differ significantly between lingua-alveolar and lingua-palatal syllables is rejected.

This hypothesis was tested in Comparison 14, /vʌ, ðʌ, zʌ/ vs. /ʃʌ/ and was significant at the 0.01 level (Table 22). Because the comparison includes syllables with places of articulation which were found to be significantly different, the significant relationship between lingua-alveolar and lingua-palatal should be viewed with caution.

> Hypothesis 7g: Rate of repetitions of syllabic utterances does not differ significantly between lingua-alveolar and lingua-velar CV syllables is rejected.

This hypothesis was tested by Comparison 5, /pʌ, tʌ/ vs. /kʌ/; Comparison 6, /pʌ/ vs. /tʌ/; Comparison 7, /bʌ, dʌ/ vs. /gʌ/; and Comparison 8, /bʌ/ vs./dʌ/ (Table 22). Significant differences at the 0.01 level were found for Comparisons 5 and 7. Syllables with lingua-alveolar plosives appear to be significantly different from syllables with lingua-velar plosives. These results are similar to those reported by Bitonti.

HYPOTHESES RELATED TO RATE AND MANNER OF FORMATION

Hypothesis 8: Rate of repetitions of syllabic utterances is not related to manner of formation is rejected for selected conditions on the basis of data reported in Tables 22, 23 and 24.

Hypothesis 8a: Rate of repetitions of syllabic utterances does not differ significantly between plosive and fricative CV syllables is rejected.

Plosives as a group were compared to fricatives as a group in Comparison 3, Table 22. Differences were highly significant (0.01). Syllables with anterior and medial plosives were compared to syllables with anterior and medial fricatives in Comparisons 2 and 5, Table 23. Differences were significant at the 0.01 level. Syllables with anterior, medial and posterior plosives were compared to syllables with anterior, medial and posterior fricatives in Comparison 2, Table 24. The differences were significant at the 0.01 level. With the exception of the velar plosive syllables, plosive syllables were produced at a faster rate than fricative syllables. These results are comparable to the findings of

Lundeen (1950).

Hypothesis 8b: Rate of repetitions of syllabic utterances does not differ significantly between plosive and nasal CV syllables is rejected under selected conditions.

This hypothesis was tested in Comparison 15, Table 22. The plosive syllables as a group were compared to the labial and lingua-alveolar nasal syllables. Differences were not significant. When /bʌ/was compared to /mʌ/ in Comparison 4, Table 22, the difference was highly significant (0.01). It may be that differences between the plosive and nasal syllables used in this study are obscured when the syllables are treated in groups. Further analysis is indicated.

Hypothesis 8c: Rate of repetitions of syllabic utterances does not differ significantly between nasal and fricative CV syllables is rejected.

This hypothesis was tested in Comparison 16, Table 22. Fricatives as a group were significantly different (0.01) from the two nasals used in the study.

HYPOTHESIS RELATED TO RATE AND VOICING

Hypothesis 9: Rate of repetitions of syllabic utterances does not differ significantly for voiced and unvoiced consonants in CV syllables is not rejected.

This hypothesis was tested in Comparison 1, Table 22; Comparison 1, Table 23; and Comparison 1 in Table 24 for the plosive syllables. None of the comparisons was significant. Differences in voicing for fricative syllables was tested in Comparison 2, Table 22. The differences were not significant.

HYPOTHESIS RELATED TO RATE AND NUMBER OF SYLLABLES IN THE TASK

Hypothesis 10: Rate is not related linearly to the number of syllabic utterances in the set of tasks is rejected on the basis of Table 25.

The effect of the number of syllables on rate was evaluated with linear and quadratic comparisons. The means of the 15 single, 15 two syllable and 15 three syllable test items were tested. Both linear and quadratic effects were highly significant ($p<0.01$). The effects are shown in Figure 5. These results suggest that an increase in the number of syllables in the test item is accompanied by an increase in rate. The highly significant F values (719.34) suggest a strong linear effect. However, the significant quadratic effect ($F = 19.84$) indicates that the increase is not constant, but changes progressively.

Apparently the increase in number of syllables and the consequent complexity of utterance result in increased interaction within the test item.

Table 25

Linear and Quadratic Effects for Length of Test Items for 15 Single, 15 Two Syllable and 15 Three Syllable Test Items for Criterion Measure of Rate (N = 120)

Effect	SS	F
Linear	417.79	719.34**
Quadratic	11.52	19.84**
Error source of variation = 5808.03 with 5192 df		

** p =<0.01

HYPOTHESES RELATED TO DURATION AND PLACE OF ARTICULATION

<u>Hypothesis 11: The duration of repetitions of syllabic utterances is not related to place of articulation when manner of formation is held constant is rejected</u> under selected conditions.

<u>Hypothesis 11a: Duration of repetitions of syllabic utterances does not differ significantly between labial and lingua-alveolar CV syllables is rejected</u> for voiceless plosives only.

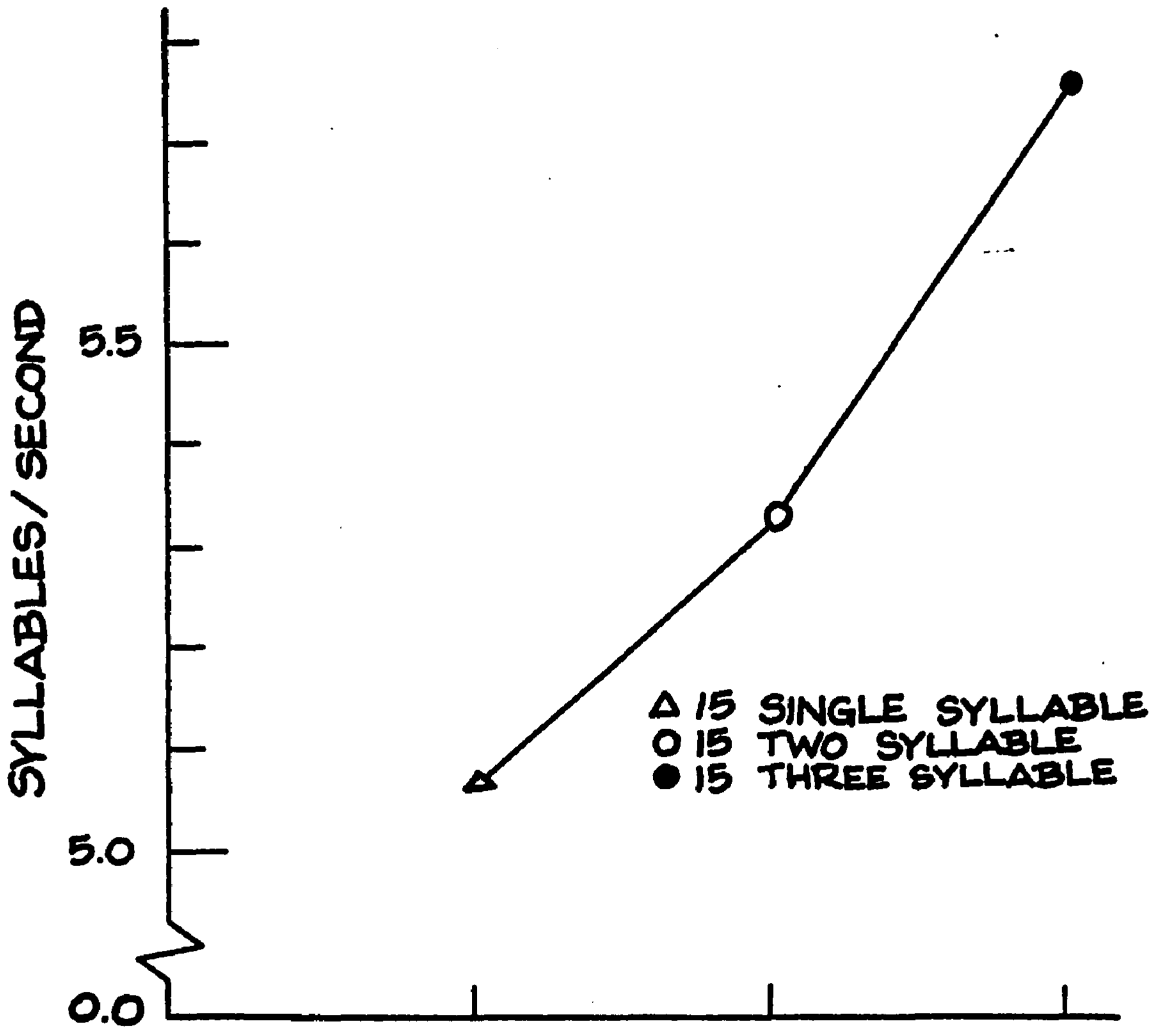

Figure 5

Relationship Among Means for 15 Single Syllable, 15 Two Syllable and 15 Three Syllable Test Items for Rate (Number of Syllables Per Second)

This hypothesis was tested in several comparisons in Table 26. Comparison 6, /pʌ/ vs. /tʌ/, was highly significant ($p<0.01$). Comparison 8, /bʌ/ vs. /dʌ/, and Comparison 13, /mʌ/ vs. /nʌ/, were not significant. The investigator cannot account for the significant finding in Comparison 6 unless the variable of voicing is relevant.

> Hypothesis 11b: Duration of repetitions of syllabic utterances does not differ significantly between labial and lingua-velar CV syllables is rejected conditionally.

Comparisons 5 and 7, Table 26, compared the labial and lingua-alveolar plosive syllables to the posterior plosive syllable. Significant differences at the 0.01 level were found for Comparison 5, /pʌ, tʌ/ vs. /kʌ/, and for Comparison 7, /bʌ, dʌ/ vs. /gʌ/. When the labial and lingua-alveolar plosives were tested for significant differences in Comparison 6 and 8, differences were significant for Comparison 6. The data in this study suggest that there is no significant difference between voiced labial and lingua-velar CV syllables. Because differences between means in Comparison 6 were significant, it is not clear whether a significant difference exists between voiceless labial and lingua-velar plosive syllables. Further statistical treatment is indicated.

> Hypothesis 11c: Duration of repetitions

Table 26

Individual Comparisons of Duration for Single Syllable Test Items (N = 120)

Comparisons[1]	SS	F
1. /pʌ, tʌ, kʌ/ vs. /bʌ, dʌ, gʌ/	1984.03	3.16
2. /fʌ, θʌ, sʌ/ vs. /vʌ, ðʌ, zʌ/	4488.01	7.15**
3. /pʌ, tʌ, kʌ, bʌ, dʌ, gʌ/ vs. /fʌ, θʌ, sʌ, zʌ, vʌ, ðʌ/	44674.69	71.20**
4. /bʌ/ vs. /mʌ/	7063.34	11.26**
5. /pʌ, tʌ/ vs. /kʌ/	18252.89	29.09**
6. /pʌ/ vs. /tʌ/	5449.25	8.69**
7. /bʌ, dʌ/ vs. /gʌ/	8997.27	14.34**
8. /bʌ/ vs. /dʌ/	28.57	0.05
9. /fʌ, θʌ/ vs. /sʌ/	2928.20	4.67*
10. /fʌ/ vs. /θʌ/	72.60	0.12
11. /vʌ, ðʌ/ vs. /zʌ/	498.00	0.79
12. /vʌ/ vs. /ðʌ/	1579.02	2.52
13. /mʌ/ vs. /nʌ/	279.93	0.45
14. /vʌ, ðʌ, zʌ/ vs. /ʃʌ/	39300.07	62.64**
15. /pʌ, tʌ, kʌ, bʌ, dʌ, gʌ/ vs. /mʌ, nʌ/	4357.08	6.94**
16. /fʌ, vʌ, θʌ, ðʌ, sʌ, zʌ/ vs. /mʌ, nʌ/	6964.02	11.10**

Error source of variation = 627.42 with 5192 df

[1]This does not represent a completely orthogonal set of comparisons

* p =<0.05

** p =<0.01

<u>of syllabic utterances does not differ significantly between labio-dental and lingua-dental CV syllables is rejected</u> conditionally.

This hypothesis was tested in Comparison 10 and 12, Table 26. No significant differences were found between /fʌ/ and /θʌ/ and between /vʌ/ and /ðʌ/. Comparison 4, Table 27, revealed significant differences between /ðʌzʌ/ and /vʌzʌ/. However Comparison 6, Table 27, did not show significant differences for /θʌsʌ/ and /fʌsʌ/. No significant difference was found in Comparison 3, Table 28, for /θʌsʌʃʌ/ and /fʌsʌʃʌ/.

These data suggest that duration for the labio-dental and lingua-dental fricative utterances may interact with the composition of test items.

<u>Hypothesis 11d: Duration of repetitions of syllabic utterances does not differ significantly between CV syllables with labio-dental and lingua-dental consonants and CV syllables with lingua-alveolar consonants is rejected</u> conditionally.

Comparison 9, Table 26, tested the differences between the means for voiceless labio-dental and lingua-dental fricatives. Differences were significant at the 0.05 level. However, Comparison 11, in which the voiced cognates of Comparison 9 were tested, was not significant. No explanation

Table 27

Individual Comparisons of Duration for Two Syllable Test Items (N = 120)

Comparisons[1]	SS	F
1. /pʌ tʌ/ vs. /bʌdʌ/	117536.88	1.87
2. /bʌdʌ/ vs. /ðʌzʌ, vʌzʌ/	732599.81	11.68**
3. /bʌdʌ, vʌzʌ/ vs. /mʌnʌ/	60984.89	0.97
4. /ðʌzʌ/ vs. /vʌzʌ/	1163768.00	18.55**
5. /pʌtʌ/ vs. /θʌsʌ, fʌsʌ/	249536.31	3.98*
6 /θʌsʌ/ vs. /fʌsʌ/	195625.25	3.12

Error source of variation = 627.42 with 5192 df

[1]This does not represent a completely orthogonal set of comparisons.

* p = < 0.05

** p = < 0.01

Table 28

Individual Comparisons of Duration for Three Syllable Test Items (N = 120)

Comparisons[1]	SS	F
1. /pʌtʌkʌ/ vs. /bʌdʌgʌ/	94470.94	1.51
2. /pʌtʌkʌ/ vs. /θʌsʌʃʌ, fʌsʌʃʌ/	1523301.00	24.28**
3. /θʌsʌʃʌ/ vs. /fʌsʌʃʌ/	222822.31	3.55

Error source of variation = 627.42 with 5192 df

[1]This does not represent a completely orthogonal set of comparisons.

* p = < 0.05

** p = < 0.01

can be offered for the inconsistent findings unless voicing is a relevant variable. The results also may reflect the high sensitivity of statistical tests with nearly 5200 degrees of freedom. It may be that /fʌ/ and /θʌ/ interaction with /sʌ/ is different from /θʌ/ and /ðʌ/ interaction with /zʌ/. Since the fricatives with anterior places of articulation are combined, the interaction between the two phonemes may obscure interpretation of the data.

> Hypothesis 11e: Duration of repetitions of syllabic utterances does not differ significantly between CV syllables with labio-dental and lingua-dental consonants and CV syllables with lingua-palatal consonants is rejected.

This hypothesis was tested in Comparison 14, /vʌ, ðʌ, zʌ/ vs. /ʃʌ/ (Table 26), and the differences were significant at the 0.01 level. Since differences in Comparisons 11 and 12 were not significant, /ʃʌ/ is significantly different from the labio-dental and lingua-dental syllables. It should be noted, that Comparison 14 also reflects differences in voicing.

> Hypothesis 11f: Duration of repetitions of syllabic utterances does not differ significantly between lingua-alveolar and lingua-palatal

CV syllables is rejected.

This hypothesis was tested in Comparison 14, Table 26. Differences between fricative syllables with labio-dental, lingua-dental and lingua-alveolar consonants and the lingua-palatal fricative syllables were significant at the 0.01 levels. Since Comparison 11 revealed no significant differences between the labio-dental, lingua-dental syllables and the lingua-alveolar syllables, the data can be interpreted to mean that lingua-alveolar and lingua-palatal syllables are different.

Hypothesis 11g: Duration of repetitions of syllabic utterances does not differ significantly between lingua-alveolar and lingua-velar CV syllables is rejected conditionally.

This hypothesis was tested in several comparisons. Comparison 5 and 7, Table 26, tested labial and lingua-alveolar plosive syllables *vs*. the lingua-velar plosive syllables. Differences for each comparison were significant (0.01). Comparisons 6 and 8, Table 26, tested the difference between labial and lingua-alveolar plosive syllables. Comparison 6 was significantly different (0.01), but Comparison 8 was not. These data suggest that voiced lingua-alveolar plosive syllables differ from voiced velar plosives. Because a significant difference was reported for the voiceless labial and lingua-alveolar plosive syllables, it is not clear from these data whether the voiceless lingua-alveolar and lingua-velar syllables are significantly different. Further investigation is indicated.

HYPOTHESES RELATED TO DURATION AND MANNER OF FORMATION

<u>Hypothesis 12: Duration of repetitions of syllabic utterances is not related to manner of formation is rejected</u>.

<u>Hypothesis 12a: Duration of repetitions of syllabic utterances does not differ significantly between plosive and fricative CV syllables is rejected</u>.

Hypothesis 12a was tested in Comparison 3, Table 26. Differences were significant (0.01). Comparisons 2 and 5, Table 27, tested the relationship for two syllable items. Comparison 2, voiced plosive syllables <u>vs</u>. voiced fricative items, was significant at the 0.01 level. The means for syllables with the voiceless cognates were significant at the 0.05 level. Comparison 2, Table 28, tested the means for three syllable sequences. Differences were significant at the 0.01 level. These results indicate that plosive and fricative CV syllables differ.

<u>Hypothesis 12b: Duration of repetitions</u>

<u>of syllabic utterances does not differ significantly between plosive and nasal CV syllables is rejected</u>.

Comparison 15, Table 26, tested the means of the plosive and nasal syllables used in this present study. Differences were significant at the 0.01 level. Plosives and nasal labials were compared in Comparison 4, Table 26, and differences were highly significant (0.01). According to these data, plosive and nasal syllables differ significantly.

<u>Hypothesis 12c: Duration of repetitions of syllabic utterances does not differ significantly between nasal and fricative CV syllables is rejected</u>.

This hypothesis was tested in Comparison 16, Table 26. Differences were highly significant (0.01).

HYPOTHESIS RELATED TO DURATION AND VOICING

<u>Hypothesis 13: Duration of repetitions of syllabic utterances does not differ significantly for voiced and unvoiced consonants in CV syllables is rejected</u> for selected conditions.

This hypothesis was tested in several comparisons. Comparison 1, Table 26; Comparison 1, Table 27; Comparison

1, Table 28, revealed no significant differences between syllables with voiced and unvoiced plosive consonants. Comparison 2, Table 26, indicated significant differences (0.01), between syllables with voiced and unvoiced fricative consonants. No explanation can be offered to account for the significant differences found for fricatives, other than the possibility of differences related to onset of voicing.

HYPOTHESIS RELATED TO DURATION AND NUMBER OF SYLLABLES IN THE TASK

Hypothesis 14: Duration is not related linearly with the number of syllabic utterances in a set of tasks is rejected.

This hypothesis was tested with linear and quadratic comparisons. Table 29 reveals that both effects were highly significant ($p = < 0.01$). These effects are shown in Figure 6. These results suggest that an increase in the number of syllables in the test item is accompanied by a decrease in duration. The highly significant F value (597.31) suggests a strong linear effect. The significant quadratic effect (139.70) indicates that the decrease in duration is not constant, but changes progressively. Some changes may be related to shifts of stress occurring when additional syllables are added to the test item. The number of syllables in the test item interacts in a complex manner with the composition of the test item.

Table 29

Linear and Quadratic Effects for Length of Test Items for 15 Single, 15 Two Syllable and 15 Three Syllable Test Items for Criterion Measure of Duration

Effects	SS	F
Linear	3747.64	597.31**
Quadratic	876.47	139.70**

Error source of variation = 627.42 with 5192 of df

** $p = < 0.01$

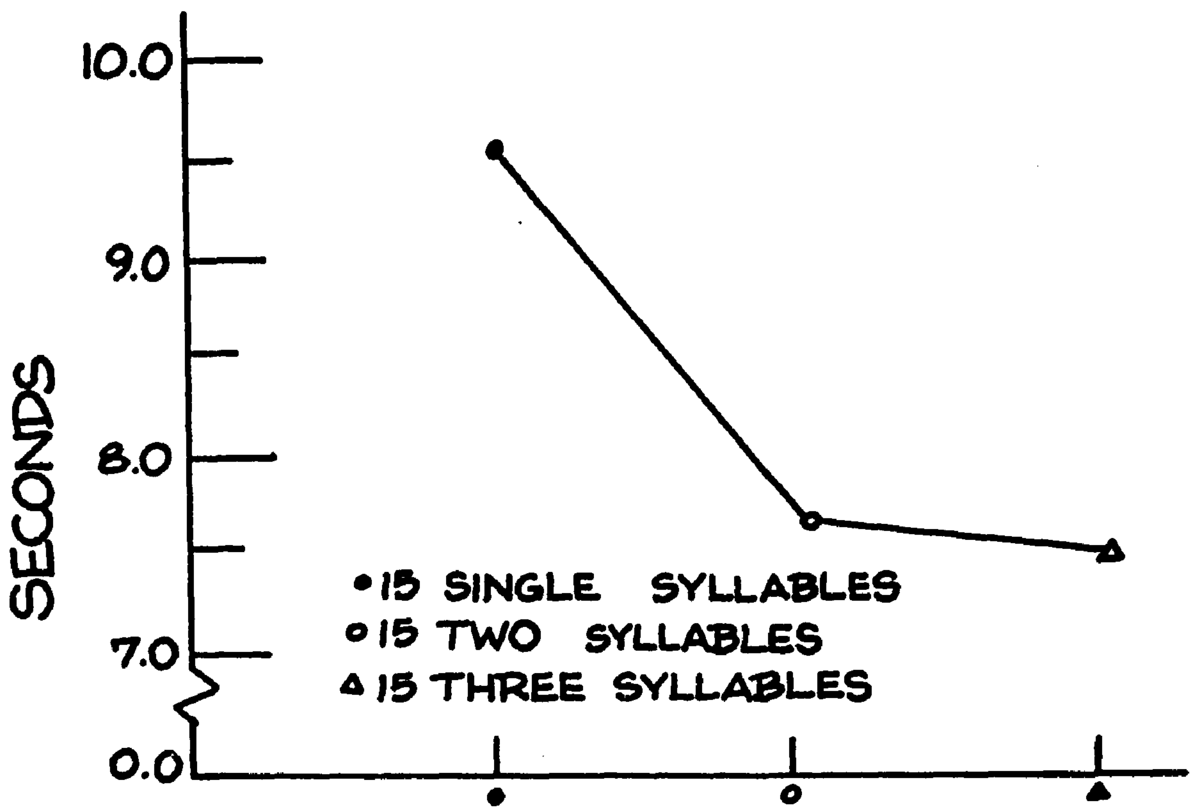

Figure 6

Relationship Among Means for 15 Single Syllable, 15 Two Syllable and 15 Three Syllable Test Items for Duration

CHAPTER V

CONCLUSIONS AND SUMMARY

The primary purpose of the present study was to investigate factors which may be significant in the employment of CV utterances for the measurement of speech motor proficiency among speakers 17 years of age with no known speech or hearing disorder.

Thirty subjects, 15 males and 15 females, repeated 45 test items as rapidly as possible for as long as possible during one maximum exhalation. Each subject repeated each test item two times during each of two test periods. Criterion measures were rate, the number of syllables repeated per second, and duration, the length of time in seconds from the onset of the first syllable to the termination of the last correctly produced syllable of a repetitive series during a single exhalation. Test items consisted of 15 single, 15 two syllable and 15 three syllable CV utterances. Factors which were studied included: sex, reliability, place of articulation, manner of formation, voicing and number of syllables in the test item.

CONCLUSIONS

Sex

Data in this current study do not reveal significant differences between the over-all performances of males and females for rate or duration. However, there are differences in performance between sexes some of the time which are obscured in comparisons of total performances of one sex with the total performance of the other sex. Males and females apparently perform differently with regard to different test times and with different test items. Since age was restricted in this study, it is not known whether males and females of other age groups perform in the same manner.

Reliability

No significant differences were found for measures obtained within test periods for either rate or duration. Duration measures tended to be more variable than rate measures, although the duration variance was not significant. These results indicate that repeated measures obtained within a test period are reliable.

The data in this study indicated that measures obtained during two different test periods are significantly different. Means for all subjects combined were higher for rate and for duration in the second testing period, which may be related to a practice effect. However, the means for each test period are highly correlated with one another (rate, $r = .94$; duration, $r = .90$). While the combined subjects produced more syllables per second and sustained their performances longer during the second test period, the relationships among subjects apparently remain stable during the test periods. Although the means are not the same, the rank order relationships among subjects appear to be the same for the two test periods. The results of this study suggest that means *per se* for rate and duration may not be meaningful without knowledge of the number of test periods. It is conceivable that means obtained from a third or fourth test period also could differ.

Test Items

The results of the present study indicate that test items were significantly different ($p < 0.01$). Differences among test items appear related to the factors of place of articulation, manner of formation, voicing and number of syllables in the test items.

Place of Articulation

Place of articulation for the CV syllables tended to interact with manner of formation for both rate and duration measures. The fastest syllables were those incorporating labial and lingua-alveolar plosives; these syllables were followed by those with labial and lingua-alveolar nasal consonants, labio-dental fricatives, velar plosive, lingua-dental, lingua-alveolar and lingua-palatal fricative consonants. When the manner of formation was held constant, syllables with posterior consonants (lingua-palatal, lingua-velar) were produced at a slower rate than anterior (labial, labio-dental, lingua-dental) and medial (lingua-alveolar) places of articulation. It is not surprising to find that syllables with velar and lingua-palatal consonants are slower in rate. These findings are consistent with the literature. There appeared to be no significant differences in the means for anterior and medial places of articulation in CV syllables with nasal and plosive consonants. Utterances with lingua-dental fricatives were significantly slower than those with labio-dental fricatives. This result was not unexpected in view of the differences in transitional movement related to increased lingual freedom in labial sounds. On the basis of data in this study, rate of CV syllables is determined in part by the place of articulation of the consonants in the syllables. Since some of the comparisons in the study reflected grouping of the anterior and posterior places of articulation, further consideration should be given to place of articulation.

Syllables with labial and lingua-alveolar plosive consonants were sustained longer than the syllables with other consonants employed in the study. These were followed by syllables with lingua-alveolar nasal, voiced velar plosive, and nasal labial consonants. The longest sustained fricative syllables were /vʌ/, /zʌ/ and /fʌ/. The syllable with the voiceless velar plosive was sustained longer than the syllables with lingua-dental fricative, voiceless lingua-alveolar and lingua-palatal fricative consonants. No definite pattern among syllables can be established for duration means, except that voiced cognates were produced for longer durations than sequences containing unvoiced consonants. This result was not unexpected.

On the basis of data in this study, the relationship between place of articulation and duration is less clear than with rate. Duration appears to be influenced more by the factors of manner of formation and voicing than by place of articulation.

Manner of Formation

With the exception of the velar plosives, syllables which incorporated plosive or nasal consonants exceeded the rate for the syllables with fricative consonants. Syllable sequences (two and three CV syllables) characterized by plosive and nasal consonants tended to be produced at a faster rate than syllables incorporating one or more fricative phonemes. These results are consistent with previous research.

Significant differences were found between syllables employing: plosive and fricative consonants; plosive and nasal labial consonants; nasal and fricative consonants. It may be that differences between manner of formation are obscured when various places of articulation represented in one manner of formation are compared with those represented in another manner.

Manner of formation was important for duration, as defined in this study, as well as for rate measures. With the exception of /kʌ/, syllables with plosive consonants had longer duration than syllables with fricative and nasal consonants. Sequential utterances of syllables with fricative consonants were continued for shorter periods of time than syllables with either plosive or nasal consonants. These results were to be expected. However, interaction with place of articulation is such that lingua-dental fricatives are sustained for shorter time periods than labio-dental sounds.

When sequences of CV syllables were compared, manner of formation did not appear to be a critical factor. Fricative, nasal and plosive syllables were distributed in such a manner among anterior and medial places of articulation that no pattern could be determined. Voicing appeared to be more important, since /pʌtʌ/, /fʌsʌ/ and /θʌsʌ/ ranked in the lower half of the 15 two syllable test items.

On the basis of the data in this present study, manner of formation is related to rate and duration means obtained for CV syllables varying by manner. These means appear to be related in part to place of articulation and voicing, since syllables employing voiceless consonants or places located more posteriorly tend to be slower and sustained for less time.

Voicing

Voicing was not significantly different for either plosive or fricative CV syllables for the measure of rate (number of syllables repeated per second). Voicing appeared to be a factor in duration for syllables with fricative consonants. Syllables with voiced fricatives were repeated for more seconds than syllables with unvoiced fricatives. These results probably are related to the fact that both the consonant and vowel are voiced, reducing the complexity of the task.

Number of Syllables in the Test Item

When single, two syllable and three syllable test items were tested for what effect additional syllables in the test item had on race, the effect was both linear and quadratic (0.01 for each). These results indicate that an increase in the number of syllables in the test item is accompanied by an increase in rate. This increase in the number of syllables per second may relate to the reduction of stress for a portion of the test item when additional syllables are added to the test item. The significant quadratic effect suggests that the increase in rate is not constant, but changes progressively. These changes may reflect differences in manner of formation and place of articulation.

Significant linear and quadratic effects were also found for the criterion measure of duration, the time in seconds that a series is repeated correctly. When the number of syllables in the test item was increased, duration was decreased. However, the decrease is not constant and may reflect differences in the composition of the test item.

The results of this present study indicate that motor articulatory performance by normal speakers is influenced by factors such as test time, interaction of sex with test time and with test item, place of articulation, manner of formation, voicing and number of syllables in the test item. Since age was not viewed as a critical variable in this study, the results cannot be generalized to all age groups. It may be that male and female speakers vary in the repetition of CV syllables differently at different ages. Normative data from other age levels and with other investigators should be obtained.

The results of this study are to be viewed as tentative. It may be that with over 5000 degrees of freedom, the statistical procedures were highly sensitive to difference. These statistical differences may not be useful in a clinical application. It may be also, that effects have been obscured by the grouping of the places of articulation, or that other groupings of the factors explored in this study might be more useful.

Developers, users and consumers of articulation tests should be aware that test results may be influenced by combinations of phonemes, by the particular sequences of phonemes and by the number of syllables in a particular sequence. It may be that the patternsof oral motor behavior observed in defective speakers are only exaggerations of the variance presented in oral motor behavior of normal speakers.

The implications of this study are that further investigation is warranted of the following factors: performances by males and females at different ages; reliability of measurements for different testing times; interaction of place of articulation, manner of formation, voicing and vowels; velopharyngeal function related to CV syllables; syllable sequences in the test item; and syllables other than CV syllables.

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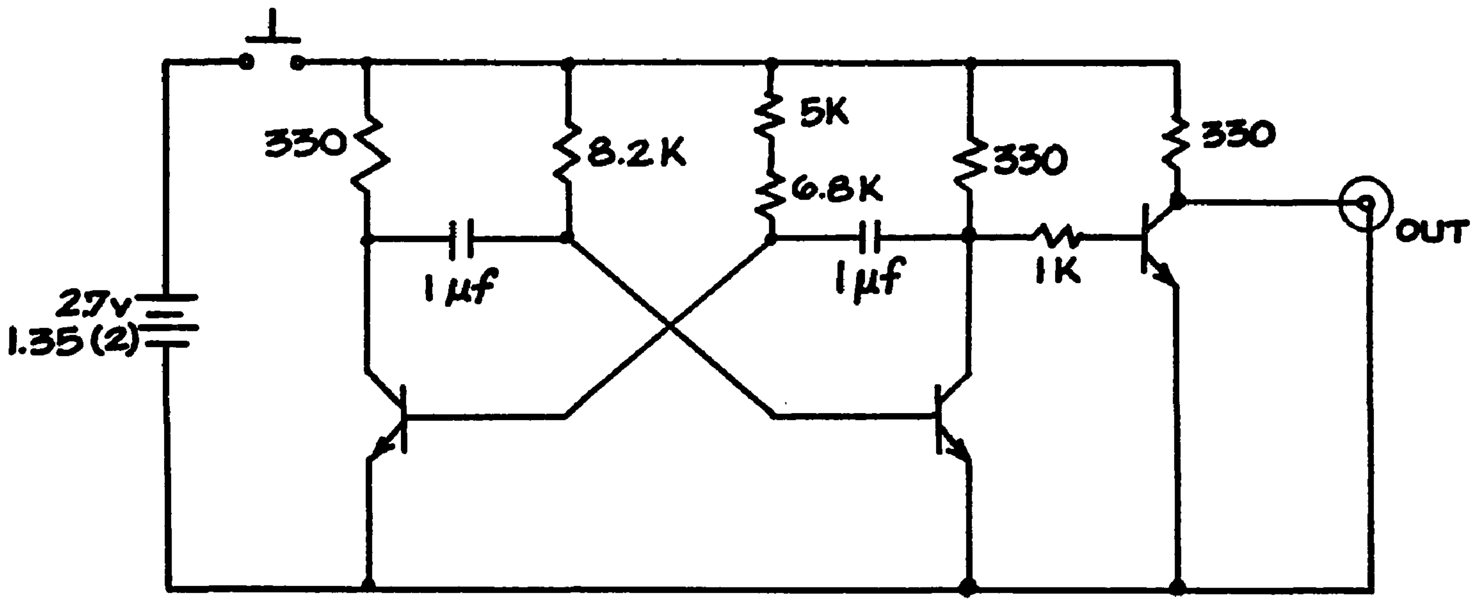

Circuit Diagram for Multivibrator

Table 30

Means, Standard Deviations, Variances, and Ranges for Criterion Measure of Rate for 15 Single Syllable Test Items (N = 120)

Item	Mean	S.D.	Var.	Range
pʌ	5.68	2.64	7.00	4.00 - 33.64
bʌ	5.53	0.62	0.39	3.79 - 6.98
tʌ	5.55	0.74	0.55	2.19 - 7.86
dʌ	5.54	0.73	0.53	3.60 - 7.81
kʌ	4.88	0.61	0.37	3.17 - 6.78
gʌ	4.86	0.60	0.36	3.12 - 6.58
fʌ	5.12	0.57	0.33	3.61 - 6.85
vʌ	5.17	0.65	0.42	1.29 - 6.78
θʌ	4.81	0.76	0.58	2.82 - 8.36
ðʌ	4.81	0.68	0.47	2.81 - 6.34
sʌ	4.64	0.65	0.42	3.14 - 6.39
zʌ	4.51	0.62	0.39	3.04 - 6.14
ʃʌ	4.53	0.62	0.38	3.24 - 6.53
mʌ	5.19	0.81	0.66	0.82 - 6.96
nʌ	5.36	0.58	0.34	3.78 - 7.28

Table 31

Means, Standard Deviations, Variances, and Ranges for Criterion Measure of Rate for 15 Two Syllable Test Items (N = 120)

Item	Mean	S.D.	Var.	Range
pʌtʌ	6.43	1.09	1.18	3.25 - 8.86
bʌdʌ	6.36	1.28	1.63	1.07 - 9.17
bʌzʌ	5.34	0.89	0.79	2.67 - 8.66
bʌnʌ	5.83	1.05	1.09	3.46 - 8.13
ðʌdʌ	4.60	0.82	0.67	2.83 - 6.48
vʌdʌ	5.69	0.90	0.81	3.54 - 7.66
ðʌzʌ	4.12	0.73	0.53	2.48 - 6.51
vʌzʌ	5.01	0.92	0.85	2.28 - 7.85
ðʌnʌ	4.84	0.82	0.67	3.45 - 7.38
vʌnʌ	5.82	0.94	0.88	3.72 - 7.87
θʌsʌ	3.82	0.68	0.46	2.45 - 6.28
fʌsʌ	4.99	1.29	1.66	2.62 - 16.22
mʌdʌ	5.51	1.19	1.42	3.03 - 8.37
mʌzʌ	5.34	0.90	0.80	3.69 - 7.89
mʌnʌ	6.12	1.17	1.38	2.56 - 9.71

Table 32

Means, Standard Deviations, Variances, and Ranges for Criterion Measure of Rate for 15 Three Syllable Test Items (N = 120)

Item	Mean	S.D.	Var.	Range
pʌtʌkʌ	6.24	0.96	0.93	3.71 - 11.50
bʌdʌgʌ	6.28	0.87	0.76	4.00 - 8.73
bʌzʌgʌ	5.92	0.80	0.64	4.05 - 7.72
bʌnʌgʌ	5.97	0.94	0.88	3.75 - 9.35
ðʌdʌgʌ	5.80	0.77	0.60	4.10 - 7.95
vʌdʌgʌ	6.23	0.87	0.76	4.04 - 8.43
ðʌzʌgʌ	5.40	0.76	0.58	3.56 - 7.44
vʌzʌgʌ	5.75	0.73	0.54	2.15 - 7.63
ðʌnʌgʌ	5.80	0.86	0.73	3.22 - 7.72
vʌnʌgʌ	6.21	0.82	0.67	3.59 - 8.82
θʌsʌʃʌ	4.10	0.81	0.66	2.01 - 5.86
fʌsʌʃʌ	4.58	0.82	0.66	1.84 - 6.38
mʌdʌgʌ	6.19	0.89	0.79	3.77 - 8.57
mʌzʌgʌ	5.84	0.72	0.52	4.14 - 7.68
mʌnʌgʌ	6.09	0.88	0.77	3.83 - 8.24

Table 33

Means, Standard Deviations, Variances, and Ranges for Criterion Measure of Duration for 15 Single Syllable Test Items (N = 120)

Item	Mean	S.D.	Var.	Range
pʌ	11.10	4.72	22.29	2.14 - 24.43
bʌ	10.77	4.92	24.21	2.41 - 32.49
tʌ	10.15	3.95	15.63	2.16 - 21.12
dʌ	10.84	5.00	24.95	2.82 - 32.29
kʌ	9.12	3.35	11.23	2.68 - 18.00
gʌ	9.75	4.14	17.11	2.63 - 22.51
fʌ	9.18	3.36	11.27	2.46 - 20.39
vʌ	9.60	4.52	20.45	2.59 - 25.46
θʌ	9.07	3.43	11.77	2.58 - 21.07
ðʌ	9.09	4.14	17.11	2.57 - 25.25
sʌ	8.52	2.74	7.51	2.72 - 18.73
zʌ	9.59	4.02	16.20	1.97 - 21.99
ʃʌ	7.33	2.19	4.79	3.07 - 15.35
mʌ	9.69	4.93	24.34	2.31 - 27.90
nʌ	9.90	4.70	22.13	2.69 - 32.07

Table 34

Means, Standard Deviations, Variances and Ranges for Criterion Measure of Duration for 15 Two Syllable Test Items (N = 120)

Item	Means	S.D.	Var.	Range
pʌtʌ	7.76	3.44	11.82	2.02 - 18.99
bʌdʌ	8.20	3.93	15.48	1.50 - 19.36
bʌzʌ	8.76	3.84	14.73	1.59 - 21.61
bʌnʌ	8.04	3.47	12.04	2.16 - 18.50
ðʌdʌ	7.10	3.09	9.56	2.04 - 15.86
vʌdʌ	7.93	3.23	10.42	2.47 - 17.02
ðʌzʌ	6.55	3.20	10.23	1.69 - 17.46
vʌzʌ	7.94	3.14	9.86	2.62 - 17.98
ðʌnʌ	7.44	2.82	7.98	2.44 - 15.81
vʌnʌ	8.48	3.33	11.10	2.43 - 18.61
θʌsʌ	6.92	2.84	8.05	2.00 - 14.01
fʌsʌ	7.49	3.04	9.23	2.06 - 16.58
mʌdʌ	6.78	3.25	10.59	2.30 - 19.96
mʌzʌ	8.41	3.60	12.96	2.28 - 17.34
mʌnʌ	7.80	3.32	11.03	1.29 - 18.66

Table 35

Means, Standard Deviations, Variances, and Ranges for Criterion Measure of Duration for 15 Three Syllable Test Items (N = 120)

Item	Means	S.D.	Var.	Range
pʌtʌkʌ	8.01	3.34	11.15	2.22 - 17.79
bʌdʌgʌ	7.62	3.55	12.60	2.27 - 21.16
bʌzʌgʌ	7.91	3.46	11.95	1.72 - 16.77
bʌnʌgʌ	8.04	3.38	11.45	2.52 - 18.55
ðʌdʌgʌ	7.64	3.19	10.20	2.00 - 16.41
vʌdʌgʌ	7.75	3.57	12.72	2.12 - 17.52
ðʌzʌgʌ	6.92	2.75	7.55	1.21 - 14.32
vʌzʌgʌ	8.18	3.24	10.48	2.65 - 17.18
ðʌnʌgʌ	7.68	3.04	9.24	2.27 - 15.89
vʌnʌgʌ	8.12	3.34	11.17	2.31 - 17.91
θʌsʌʃʌ	6.33	3.06	9.38	1.90 - 15.89
fʌsʌʃʌ	6.94	2.67	7.10	2.39 - 14.23
mʌdʌgʌ	6.29	3.02	9.10	1.19 - 14.63
mʌzʌgʌ	7.68	3.47	12.07	2.43 - 20.12
mʌnʌgʌ	8.01	3.37	11.38	2.35 - 15.95

VITA

Elizabeth Jane Allen was born August 7, 1938 in Stafford, Kansas, to Delphian and Elbert Allen. She completed most of her elementary and secondary education in Bellevue, Washington, graduating from Bellevue Senior High School in 1956. She received a Bachelor of Arts degree in 1960 from Seattle Pacific College, Seattle, Washington, and a Masters of Arts degree in 1962 from Louisiana State University, Baton Rouge, Louisiana. Her major for both degrees was speech.

She continued her graduate education in speech pathology and psychology at Louisiana State University until she accepted a position at Wisconsin State University - River Falls, River Falls, Wisconsin, in 1963. She returned Louisiana State University in 1966 as an Office of Education Trainee in Speech Pathology. From September, 1968, to June, 1971, she was an assistant professor in the Department of Special Education, San Jose College, San Jose, California. She moved to San Diego State College, San Diego, California, in the fall of 1971 where she is currently employed as an assistant professor in the Department of Speech Pathology and Audiology.

EXAMINATION AND THESIS REPORT

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Major Field: Speech

Title of Thesis: An Ivestigation of the Criterion Measures of Rate and Duration During Performance of Selected Articulatory Motor Tasks by Normal Speakers

Approved:

Gene H. Gunn

Major Professor and Chairman

Max Goodrich

Dean of the Graduate School

EXAMINING COMMITTEE:

Susan Lytle Gilmore

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Date of Examination:

May 13, 1972